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A Performance and Systems Audit of The Acidic Precipitation in Ontario Study Monitoring Networks

Volume 1 and Volume 2 (Appendices)

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Prepared For

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EXECUTIVE SUMMARY

This quality assurance audit of the Ontario Ministry of Environment's Acidic Precipitation In Ontario Study (APIOS) monitoring programmes was commissioned by the Air Resources Branch to provide an independent review and evaluation of the operating and quality assurance procedures for the monitoring networks.

The systems and performance audits of the APIOS programmes were carried out during the spring and summer of 1982 to evaluate all of the major aspects of the monitoring systems. The areas of the operating and QA/QC systems of the cumulative and event precipitation monitoring programmes and the daily and cumulative air sampling networks that were evaluated included:

1) The existing quality assurance plan and procedures
2) Network design and site representativeness
3) Network operating systems and instrumentation
4) Data collection and validation procedures

5) Laboratory procedures for sample analysis and quality assurance.

The results of the audit programme indicate that in general, the operating procedures that have been implemented for the networks provide a sound system for the collection of representative data. The monitoring locations employed in the programme were generally well sited, and the procedures and instrumentation employed were developed recently and modified further to ensure the sample integrity and collection characteristics. The development of data validation procedures has not currently been completed for all monitoring data. To date, only the event precipitation data collected from September 1980 to December 1981 have been validated and published. The laboratory QA/QC procedures appear to be well conceived and have been implemented for all areas of sample analysis. The turn-around time for the air sampling filter analysis should however be improved to ensure that sample degradation does not occur.

The basis of a quality assurance and quality control system has also been established. In particular, positive steps towards the collection and assurance of quality data have been taken through the development of a quality assurance plan and the appointment of a quality assurance co-ordinator. The fact that this audit and review has been requested also reflects that the need for quality assurance is perceived by network management to be an important element of the monitoring programme.

However, some aspects of a detailed quality assurance programme and routine quality control system have not been implemented to date and are identified and discussed in this report.

This report summarizes the status of the network operations and quality assurance procedures for various areas of the programme and indicates which areas of the systems require more development. Specific recommendations for the development of operating and QA/QC systems are provided for each element reviewed and are summarized in Section 7 of this report. Some of the more significant recommendations are:

1. The existing quality assurance programme and plan should be revised and restructured to include all important elements of quality assurance. The network and laboratory quality assurance co-ordinators should work closely together to ensure that routine procedures are implemented to determine the accuracy, precision, completeness and representativeness of the data reported by the network.

2. Reports on the activities and results of the quality assurance procedures should be reported on a regular basis. These reports should include discussions of data quality.

3. Data validation and reporting procedures should be developed for all areas of the programme to ensure that all data are validated and distributed to users as quickly as possible.

4. The network documentation system should be redesigned and distributed to all members of the programme.

5. Development and evaluation of the instrumentation employed in the programme should continue.

6. Quality assurance procedures should be implemented for all future special studies programmes.

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1.0 INTRODUCTION

These audits of the Acidic Precipitation in Ontario Study (APIOS) activities were carried out to perform independent reviews of specific areas of the monitoring programme and to evaluate the efficiency of the overall quality control and quality assurance systems that have been implemented to date. In requesting this audit, the APIOS network managers have recognized the need for sound operating procedures and quality control systems and the periodic review of them.

The terms QUALITY CONTROL and QUALITY ASSURANCE may be defined in many ways. Quality control (QC) is most accurately defined as a system of routine checks and procedures included in normal operations to ensure a quality product, while quality assurance (QA) may be defined as a system of external activities performed occasionally to ensure that the quality control programme is performing adequately. While the general objective of the APIOS monitoring programme is to quantify wet and dry deposition across the Province of Ontario, the objective of the quality assurance programme should be to improve the quality of the data collected and to provide data that is complete, precise, accurate and representative. The data collected from these networks may be used to support policy decisions and monitoring observations that must be scientifically defendable. It is therefore important that they are of known quality. If these data are to be used with data collected by other networks to observe larger scale and longer term effects, the completeness, accuracy and precision of the data must be known and reported.

Quality assurance guidelines and recommendations have been prepared for ambient air monitoring network operations, and specific regulations regarding QA procedures exist for many specific measurement techniques. While quality assurance programmes are important in these applications, they are of particular importance in the operation of precipitation sampling networks because of the nature of the sampling systems used, the length of the sampling periods, and the potential for contamination from numerous sources. For example, even the most heavily polluted rain sample represents a very dilute solution in terms of the concentrations of various parameters present.

The amount of lost data is also of prime importance. In the case of month-long, cumulative sampling for example, one lost or voided sample represents about 8 % of a year's worth of sampling. In addition, if the data lost correlate with a particular type of precipitation event or weather condition (for example very heavy rain or extreme cold) a systematic bias will be present in the results.

During the preliminary stages of the audit programme, a prelimary evaluation of the network systems was undertaken to assess the priorities for the audits and to decide which areas should receive the greatest level of effort. It was decided that the priority of the evaluation would be as follows:

1) existing quality assurance procedures

2) network representativeness and siting
3) field operations including instrumentation, operators and sample custody
4) data handling and validation techniques
5) laboratory sample analysis and QA/QC procedures

These priorities reflect the relative level of effort that was applied to each area examined during the audit programme.

The very nature of a quality assurance audit and evaluation demands that it be a critical assessment of the operating and QA/QC procedures employed. There are obviously a number of constraints under which the APIOS programme must operate at both the operational and administrative level. The auditors were aware of some these problems; however, there were many areas in which the constraints on the network resources were unknown. The approach to the audits has therefore been to provide an overall assessment of the individual systems reviewed, to illustrate potential problem areas, and to recommend corrective action or guidelines for corrective action schemes wherever possible, regardless of known or unknown constraints.

The report has been structured to discuss the priority areas of the APIOS programme in separate chapters. Each chapter consists of a brief description and summary of the system under review, an overall assessment of the results of the systems and performance audit, and specific recommendations for consideration in improving the system.

The evaluation of the existing quality assurance system is presented in chapter 2 and the network siting and representativeness are discussed in chapter 3. The major areas of the network monitoring programmes are evaluated in chapter 4 followed by the data handling and laboratory analysis in chapters 5 and 6 respectively. A summary of the audit results and recommendations is presented in chapter 7.

2.0 EXISTING QUALITY ASSURANCE PLAN AND PROCEDURES

One of the major portions of the quality assurance audit programme was to document and evaluate the quality assurance plan and procedures of the APIOS programme. This review was essential to plan and prepare for the specific areas of the system and performance audits as well as to provide an overall evaluation and review of the QA plan.

The purpose of the QA plan should be to provide a description of the steps that must be taken to ensure that the data collected by the network are of highest possible quality. The QA plan should provide a mechanism for ensuring that the data that are collected are representative, complete, and of known accuracy and precision. These aspects of data quality are particularly important in ensuring the comparability of data collected by different networks.

The QA plan should consist of specific documentation designed to present the quality control procedures that are to be implemented as part of routine operations, as well as the non routine (quality assurance) checks that will be performed to ensure that the quality control steps are working, and indeed, providing a quality product. The QA plan should be structured so that all of the critical areas of the programme are readily identified, and the specific quality assurance and quality control steps associated with them described.

In particular the quality assurance plan should address the QA and QC procedures and objectives of the following areas of the monitoring programme.

- Statement of QA Objectives - precision, accuracy, representiveness completeness, comparability.
- Network Management - including manpower structure and reporting.
- Network Representativeness - design and siting criteria
- Network Documentation and Document Control
- Instrument Procurement and Pre-testing
- Training
- Sample Collection and Handling Procedures
- Instrument Calibration and Maintenance Procedures and Frequencies
- Sample Analysis
- Data Management Systems
- Data Validation Procedures
- QA Co-ordination and Management
- QA Reporting
- Corrective Action Procedures
- Auditing Procedures

The audit and review of the APIOS QA plan and procedures revealed that the following steps had been taken towards the implementation of a complete quality assurance and quality control system:

1) A quality assurance plan and responsibilities outline has been written and distributed (7) to address many of these quality assurance elements.

2) A quality assurance co-ordinator has been appointed to oversee the implementation of the QA plan and the development of the specific QA procedures.

3. QA procedures have been implemented for some stages of the programme.

4. The QA/QC procedures for laboratory sample analysis are well established and implemented.

5. A quality assurance audit of the programme has been commissioned to review and evaluate the effectiveness of the programme.

The implementation of these steps indicates a network commitment to the collection and reporting of quality data. Further development of specific QA/QC elements should result in the establishment of a complete quality assurance system.

The review of the existing APIOS QA plan revealed a document that addressed a number of the important quality assurance factors described above. The existing plan provides detailed and specific procedures for some of the QA elements, whereas others are simply mentioned and specific details not provided. For example, the requirements for site documentation, instrument and sampling logs, and parts of the systems and performance audits are described in detail. However, the requirements for other areas of the programme such as operator training and proficiency checks, sample handling and storage procedures, inventory requirements, and, calibration and maintenance procedures and schedules are not specifically described or referenced. In addition, a number of important quality assurance elements are mentioned in the introduction to the plan (including instrument checks, operator evaluations, corrective action schemes and laboratory QA) that are not discussed at all within the body of the plan.

The presentation of the plan is also difficult to follow. The existing structure has the QA plan in one document and the QA responsibilities outline in another. This leads to confusion and duplication. The structure of the plan itself is also somewhat confusing since a number of QA elements are grouped under the wrong general category (eg. instrument and operator performance do not belong under the heading "Representativeness of Network").

The implementation of the QA plan and procedures was also evaluated to examine the level to which they had been incorporated into the network operating procedures. The specifics of these evaluations are presented for various parts of the programme in sections below. In general it was found that basically sound operating procedures were observed, however, the routine QA/QC steps mentioned in the QA plan were often not incorporated into the routine network operations. In developing the quality assurance plan and updating the QA programme for the APIOS monitoring system, the QA elements should be examined and the following questions should be answered:

> Which of the operating areas are the most critical?
> How should they be checked?
> How often should they be checked and by whom?
> What steps should be taken if unacceptable results are obtained?

It is recommended that the following points be considered in the development of the new plan.

1) The plan should be restructured and reorganized so that it addresses all important QA elements of the programme. Detailed checks and routines should be presented for each stage of the programme. Statements such as "periodic spot checks" and "adequate supplies" should be replaced with specific instructions, schedules and references to documented procedures as required. The structure should permit the distribution of individual portions of the QA/QC procedures as

well as allowing for the integration of all QA procedures into one document.

The QC procedures to be implemented as part of routine operations should be described and should be incorporated into the network documentation. The QA plan and procedures and routine network operations should be contained in separate documents and cross referenced as required.

The plan should be circulated to all members of the programme along with a statement from the head of the programme stressing the importance of quality control and assurance.

2) The QA/QC responsibilities for all staff should be documented and distributed to all members of the programme. Training procedures and schedules should also be documented for all levels of the programme.

3) The plan should tie the field monitoring and laboratory analysis quality assurance programmes more closely together in order to obtain an integrated, overall evaluation of the QA/QC steps for the APIOS programme. Additional procedures should be developed including routine evaluations of sample containers, and routine submission of duplicate, spiked and blank samples from the field.

4) The requirements for quality assurance reports should be identified and scheduled. Some of the important areas to be discussed in the QA reports include:

- data recovery and reasons for lost data
- summary of QA activities and results
  - new activities
  - accuracy and precision
  - level of QA effort
  - round robin intercomparisons
- appraisal of QA effort with respect to network performance
- status of major QA problems and anticipated action (schedules)
- list of revisions to QA or operational procedures

5) Specific QA/QC procedures should be developed and documented for data screening and validation. The use of control charts is strongly recommended.

6) Schemes should be developed for the corrective action procedures to be taken in solving QA related problems.

7) The quality assurance co-ordinator's duties and responsibilities should be documented.

8) Once the QA plan has been developed and the specific QA steps identified, they should be prioritized in terms of monitoring objectives and resources available. A schedule should be generated to identify which steps should be incorporated and when.

9) The quality assurance plan and procedures should be circulated to and compared with, those used by other networks to assess the comparability of data collected.

3.0 NETWORK REPRESENTATIVENESS

The representativeness of the monitoring networks within the APIOS programmes were evaluated in terms of the stated network objectives and standard network design and siting procedures. The objectives of the monitoring networks have been defined and documented in several reports (1, 2, 3) and may be summarized as follows for the various programmes:

a) Event Wet/Dry Deposition

- to study the composition, frequency and intensity of precipitation events in Ontario
- to determine the wet deposition of acid related materials associated with air masses originating from different emission source regions
- to determine the amounts and origin of airborne, acid related pollutants available for deposition on a daily basis
- to estimate dry deposition rates of these pollutants on a daily basis using airborne concentrations and appropriate deposition velocity estimates

b) Cumulative Wet/Dry Deposition

- to study the chemical composition of precipitation samples collected on a cumulative (28 day) basis in Ontario
- to determine the long-term wet deposition and distributions of various chemical parameters across the province
- to determine the amount of airborne acidic pollutants available for deposition in Ontario on a cumulative basis (28 day)
- to estimate the dry deposition rates of these pollutants on a cumulative (28 day) basis by using the airborne concentrations and appropriate deposition velocity measurements

Two separate networks have been designed to meet these monitoring objectives. The daily (event) precipitation monitoring network consists of four clusters of samplers within different regions of the province in order to make measurements on spatial scales varying from local to regional to provincial. These clusters are located in the Atikokan, London, Dorset and Kingston areas. The latter three are located along the prevailing flow direction for southern Ontario, and the former at a sensitive, background monitoring location. Each of these clusters consists of four samplers, with two pairs of two samplers. The pairs of samplers are separated by 50 - 100 km (regional), while the individual sites within a pair are separated by 5 - 10 km (local). Duplicate samplers are employed at one site in each region to provide a measure of the precision associated with the precipitation measurement technique. Daily air sampling is carried out at one monitoring sites in each region.

The cumulative monitoring network was designed to monitor across the entire province with the highest density of samplers in regions of highest expected and known deposition (based on historical measurements and long range transport modelling) and susceptibility to acidic deposition. Totals of 36 cumulative precipitation monitoring and 23 cumulative air sampling sites are now operating. The air monitoring sites are co-located with precipitation collectors.

The actual distribution of sites within the networks generally follow these design guidelines. One exception is the distribution of the event sites in the northwestern region in which the spacing between the individual samplers in the pairs is greater than 5 - 10 km as a result of a lack of good sampling sites in this sparsley populated area.

The systems audit carried out as part of the evaluation of network representativeness consisted of a review of the network siting criteria (as documented in network procedures (1, 3)), an examination of the site documentation available, and a review of on-going checks of the suitability of the sites carried out as part of routine operations.

The performance audit of network representativeness consisted of site evaluations and ranking based on a detailed set of evaluating criteria. The results of these two types of audits are presented below.

3.1 Systems Audit of Network Representativeness

3.1.1 Site Documentation

Detailed site documentation is required to provide a description of the site and its instrumentation, information on site specific factors that may influence sample integrity, and details of historical site evaluations and problem areas.

The information that is required as part of a complete site documentation package includes the following:

- topographical maps showing site location
- site co-ordinates (UTM or Latitude and Longitude) and elevation
- detailed site description including
    - sampler configuration
    - electrical configuration

  - obstructions
  - access
  - potential contamination
  - ground cover
- labelled photographs of site (cardinal directions) and equipment
- list of instrumentation (including serial numbers)
- summary of deviations from siting criteria or guidelines
- written summary of positive and negative aspects of the site

The results of the review of the existing site documentation (March 1982), carried out by the auditors are presented in Tables 1 to 4 and 5 to 9 on a regional basis for the event and cumulative networks respectively. The documentation that was available generally consisted of drawings and site description forms completed at the site selection or installation stages, brief evaluations (of sites, operators and equipment) carried out after the network had started up, and site photographs taken at various stages of the network implementation.

Site documentation packages were available for the majority of the APIOS sampling sites. With the exception of the missing data noted in Tables 1 to 9, the documentation packages addressed the following areas in detail:

- site location and access
- electrical configuration
- obstructions to sampling
- ground cover
- potential local contamination (houses, industry, etc.)
- access by operator
- security

The format of the documentation presented often varied from site to site, which makes intercomparisons between sites difficult in some cases.

Information that was not generally available for the sites included:

1) a list of the monitoring equipment currently operating at the site and the relative locations of the various monitors

2) labelled site photographs illustrating the nature of the site and the instrumentation

3) details of potential sources on a regional basis (for example, within 50 km of the site)

4) a detailed description of ground cover and soil type at the site

5) description of the characteristics of the wind break at the site

6) description of local and regional topography

7) list of any deviations from siting criteria and a summary description of the advantages and disadvantages of the site

8) a current site (and operator) evaluation

All of this information is required in a site documentation package to ensure that a current, detailed site description is available for all sites. This detailed, site specific data should be presented to assist in evaluating questionable data from individual sites.

3.1.2 Site Selection and Evaluation

The monitoring sites employed in the APIOS sampling programme were chosen by various members of the programme according to siting criteria documented in start up documents (3, 4) and separately prepared site inspection and evaluation forms. A copy of the APIOS siting criteria check list is presented in Figure 1. The site selection criteria presented in these documents were generally found to be complete and addressed the following areas:

- obstructions to sampling
- logistics and access
- topography
- potential sources of contamination
    - transportation sources
    - agricultural activity
    - local industry
- ground cover
- wind break
- security

These checklists provided a means for ensuring that all of the sites were evaluated with respect to a consistent set of criteria. The check lists however, do not necessarily ensure that the required information is obtained in sufficient detail when completed by inexperienced personnel. An example of a more detailed list of site evaluation and selection criteria may be found in Appendix I which contains the site description questionnaires used during the site inspection audits.

The original site evaluations were carried out during the site installation period. All sites were approved at this stage by the network co-ordinators prior to installation. Supplementary qualitative evaluations were also carried out by the regional technicians to provide periodic assessments of the site, operators and instrumentation. These qualitative site evaluations (as presented in Table 10) provide a means of ensuring that the monitoring sites remain up to par, and of documenting any changes or recurring problems that may require attention. They have not, however, been carried out with a standard set of evaluating criteria, nor have they been reviewed by a single person (or committee) to provide a consistent evaluation over all regions.

3.2 Performance Audit of Network Representativeness

Site evaluations were carried out at twenty three of the fifty five regular (not including special study sites) APIOS monitoring stations. These visits included 10 event sites and 16 cumulative monitoring sites.

The sites selected for the audit program were chosen at random by the auditors after reviewing the site description and historical evaluation documents. The sites were chosen on a regional basis ensuring that the number of event and cumulative sites visited was roughly proportional to the total number of each type of site. The list of sites selected was then reviewed and slightly revised by the network QA co-ordinator and manager to ensure that questionable or problem sites were included in the audit programme wherever possible. The list of sites inspected is presented in Table 11.

The site visits included audits and evaluations of the site, operator, sample and data handling procedures, plus configuration and calibration checks on the instrumentation. The questionnaires and audit check lists used during the site visits are presented in detail in Appendices I to V. The results of the audits and overall evaluations of the sites are summarized and presented in Appendix VI. Each of the site evaluations includes a semi-quantitative score (out of 10) for the following categories: site configuration, operator and instrumentation. The details of the operator and instrumentation checks and results are presented in separate sections below.

The overall evaluation of a given site was determined by reviewing these results and evaluations. The overall site ranking was not done as a simple aggregate of siting, operator and instrument scores since factors such as contamination by local sources or improper sample handling techniques must be weighted more heavily than instrument or logistical problems (i.e. the instrument could be replaced). The site rankings also take into consideration the regional constraints that may have forced compromising the site selection criteria in some areas.

The majority of the sites visited were well sited and met most of the APIOS siting criteria. In some cases, previously well-sited locations had deteriorated due to the construction of some type of obstacle or potential contamination source near the samplers. In general, the cumulative and event monitoring stations were equally well-sited. The primary event monitoring sites that included daily air sampling measurements (Ely-Minn (NW), Longwoods (SW), Dorset (Central) and Charleston Lake (SW)) were found to be particularly well sited with good ground cover, few obstructions and reasonably complete windbreaks surrounding the site.

Each of the sites inspected has been given an overall rank of; 1. good to excellent - indicating no significant deviations from siting criteria, 2. fair to good - indicating some deviations from criteria and 3. poor - indicating significant deviations from siting criteria resulting in potential contamination or obstruction of samples. The results of these rankings are presented in Tables 12 to 15 on a regional basis. The details of the on-site evaluations are presented in Appendix VI.

The sites that have been classified as poor are discussed in more detail below and where applicable, site changes are recommended. The importance of these deviations from the siting criteria should be evaluated and action taken to correct the faults or qualify the data collected at these sites.

1. Mattawa (Northeastern Region)

The cumulative monitoring site at Mattawa (Figure 2) was judged to be unacceptable due to the poor ground cover (loose sandy soil) at the site, and the fact that the operator regularly incinerated garbage at a small fireplace near the low volume air sampler. The operator stated that he occasionally covers the precipitation sampler at these times, but does nothing to protect the air sampler.

This site could be greatly improved if grass were planted on the sandy soil and arrangements made to prevent the garbage incineration near the sampler.

2. Smiths Falls (Southeastern Region)

The cumulative site at Smiths Falls is located in a flat, grass covered, open area in a school yard. Formerly this was a good monitoring site with an excellent operator. However, there has recently been an extension of power service from the main school buildings to portable buildings located beyond the APIOS monitoring site. The overhead power lines that were used to complete this job pass almost directly over the precipitation sampler and a hydro pole has been installed immediately adjacent to the sampler (Figure 3).

The overhead line and hydro pole obviously do not meet the network siting criteria. Removal of the line (by burying cables) or selection of an alternate site should be considered. If this site is maintained (in order to preserve continuity of data) a special study should be undertaken to determine if there are any observed effects of the hydro line and pole and the data should be flagged accordingly.

3. Nakina (Northwestern Region)

The cumulative site at Nakina was probably the least representative of the sites visited. The sampler is meant to measure the precipitation and air quality parameters in a very remote region of the province (150 km north of Lake Superior) and yet it is located in a highly built-up, urban-like area. The sampler is located in a residential subdivision in the middle of the town (population 1000). In addition, overhead power lines pass directly over the precipitation sampler (Figure 4). The major industry in Nakina is a railroad marshalling yard for the Trans-Canada railroad route. The operator indicated that the diesel emissions from the trains can be detected throughout the entire town - particularly during stable conditions in the winter.

It is strongly recommended that the data collected to date be carefully evaluated and that this site be relocated in order to collect more representative samples.

4. Lac La Croix (Northwestern Region)

The Lac La Croix cumulative monitoring site is located at a fishing camp near the Quetico Provincial Park on the Ontario-Minnesota border. The sampler is located on a bridge approximately 4 meters above the water surface of a small bay (Figure 5). This sheltered area is used as a harbour and float plane base for the fishing camp and trading post located on the bay. This results in a large amount of plane and boat traffic immediately adjacent to the samplers. In addition, the samplers are located on a foot bridge at approximately 'eye level' resulting in poor security and potential contamination from passers by.

There was also evidence of historical operator problems at this site, and poor sample handling procedures and improper sampling times were observed during the audits. It is suggested that a new site be considered for this area.

5. Railton (Southeast Region)

The Railton event monitoring site is located on a large grassed clearing surrounded by deciduous trees. During the audit visit a garage was under construction immediately east of the samplers. There was evidence of considerable construction activity (Figure 6) at the site and the resulting structure would provide a considerable obstacle and source of potential contamination to the samples.

This site could be transformed back to a good site by simply moving the samplers an appropriate distance from the building.

3.3 Network Representativeness - Summary and Recommendations

The system and performance audits of network representativeness and siting have illustrated that the APIOS networks have been designed to meet the stated network objectives. The siting criteria that have been developed are basically sound and have, for the most part, been followed during the site selection and installation process. There are however, some noteable exceptions which have been discussed above.

The review of site documentation revealed that a preliminary documentation package was available for the majority of the sites. Some of the areas not included in the site documentation have been discussed.

Site evaluations and rankings are performed periodically (by the regional technician) in an attempt to monitor and maintain the site quality. The basis for these evaluation rankings (from best to worst,) however, has not been well defined and does not seem to be consistent from region to region. A more formal evaluation procedures with more scientific input is required to make objective evaluations.

The recommendations arising as a result of the audits of network representativeness are presented below:

1) A standard site documentation package should be designed and completed for each site to include the following information
    - description of on-site monitoring equipment
    - current, labelled photographs of the site and instrumentation
    - details of potential sources on a regional basis
    - detailed description of ground cover and soil type at the site
    - list of deviations from siting criteria and a summary of the good and bad points about the site
    - a current site and operator evaluation based on standard guidelines

2) Standardized site evaluation procedures should be implemented and performed to address specific site, operator and instrumentation characteristics. These evaluations should be performed on a regularly scheduled basis (perhaps as part of future audits) to ensure that an up-to-date evaluation is present for all sites. The evaluations should be reviewed by the QA co-ordinator to ensure that quality samples are being collected and to permit the application of consistent ranking criteria with respect to sound scientific principals.

3) The monitoring sites that have received poor or marginal ratings should be evaluated in detail. The characteristics resulting in these rankings should be investigated to determine whether or not the site should be discontinued, modified or the data collected from it, flagged.

4) One possible way to assess the impact of poor siting on data collected would be to establish additional, properly sited instruments near the existing monitors. If no significant differences are observed, it may be possible to maintain the data collected from original samples with qualification, and thereby collect uninterrupted data at one site.

4.0 NETWORK OPERATIONS

The systems and performance audits of network operations included qualitative and quantitative reviews of the pre-sampling and sample collection stages of the monitoring programme. During these audits the operating systems for event and cumulative, wet and dry sampling programmes were reviewed and evaluated. These evaluations included a review of the details of the instrumentation and sample handling procedures for the networks, an evaluation of the documentation used to describe these procedures, visits to the local operators and regional technicians (to ensure that the procedures were followed) and evaluations of individual sampler performance.

The network operating procedures were evaluated by reviewing documentation available, discussions with network managers and QA co-ordinator, and first hand observation of the procedures used in the field. The operating procedures for each of the four monitoring programmes (cumulative precipitation, event precipitation, daily air sampling and cumulative air sampling) have been summarized and the results of the systems and performance audits are presented below. These discussions of individual sampling programmes are followed by a discussion of the audit results of areas common to all parts of the programme (eg. network documentation, operator training and overall monitoring structure).

4.1 Cumulative Precipitation Sampling Procedures

4.1.1 Instrumentation

The cumulative precipitation monitoring programme employs the M.I.C. Type A or Sangamo Type A Wet/Dry Collector with polyethylene bag inserts to collect precipitation over a 28 day sampling period. The dry side bag is employed to collect dry deposited material over the same period. A number of instrument modifications have been incorporated into the sampler to improve the sampling characteristics and maintain sample integrity. These modifications include:

1) A pliable, inert silicon gasket has been attached to the underside of the stainless steel, movable hood to form a tight seal between the collector and the hood which prevents evaporative loss of sample and contaminants from entering the sample. The gasket also helps prevent contamination of the sample as a result of sample evaporation followed by condensation on the underside of the metal hood and with drops falling back into the sample.

2) Polyethylene bags are inserted into the collector buckets to provide clean, pristine sampling containers for each sample. This circumvents the problem of accumulation of particulate and organic material on the bucket and also eliminates the

time consuming, multiple bucket washes required between samples. The bags also help improve and standardize the sample handling and shipping procedures.

These bags were subjected to intensive laboratory testing (6) prior to use and were found to have no significant contaminants. There was no absorption of ionic species from the collected samples observed. However, some metals were absorbed onto the bags. Acid leaching is therefore required for samples in which metals analyses are required.

3) A knife edge collar is attached to the top of the sample container to hold the bag in place and provide a very narrow edge to the container which improves the aerodynamics of the sample. This also reduces sample contamination by reducing rain drop splash and pick up of contaminants from the underside of the hood.

4) A longer sampling tube and bag is used for winter time collection to reduce the snow "blow-out" effect.

5) The sensitivity of the precipitation sensors has been standardized to a given resistance (220 kΩ) to ensure that all of the samplers in the network will respond in a similar fashion to the same type of precipitation.

4.1.2 Sample Handling Procedures

The cumulative precipitation monitoring stations are located and operated under various conditions across the province. The background of the operators employed varies from trained Ministry of the Environment technicians and high school science teachers to provincial park employees and private citizens. In order to compensate for the varied background of the operators, sample handling procedures have been devised to reduce sample transfer steps and eliminate potential sample contamination problems such as touching the inside of the container with fingers, touching the precipitation sample, dropping things into the sample or spilling the sample. Some of the more important details outlined in the sample handling procedures and the steps taken to avoid contamination or sample loss are described below:

- all samples are collected every 28 days between 0700-0900 hours local time
- disposable gloves are worn to change sample bags and handle any surfaces that contact the sample
- bags are handled on outside surfaces only during installation and removal of sample bags (for wet and dry side bags)

- separate procedures are provided for summer and winter operations

- bags are immediately tied upon removal from the sampler

- disposable gloves are changed each time they must come in contact with any surface that touches the sample

- procedures are described to ensure that the insertion of the new bags results in a well fitting bag. Bags should go to the bottom of the container and the bag at the orifice should be flattened so that the orifice size is not reduced and precipitation does not gather at the top of the container where it may be blown away

- specific instrument checks are prescribed so that the operators may check instrument performance each time samples are removed. These include:
  - gasket seal
  - delay time
  - sensor grid operation
  - visual checks during events

- operators are instructed to contact regional technicians at the first sign of instrument problems

- technicians are instructed to visit sites as often as possible (monthly is recommended) for instrument checks, discussions with operators and sample pick-up

- a precipitation bulk storage gauge (with an oil layer), is used to measure the precipitation amount since the collection efficiency of the Sangamo varies. Operators are instructed to ensure the gauge remains level, check for debris (correction procedures are identified) and record the solution temperature for temperature correction. The technician is responsible for ensuring the gauge remains at a constant height above ground (or snow pack) and for providing appropriate solutions for summer and winter operations

- detailed operator sample submission forms have been developed to document sample characteristics including:
  - sample identification
  - storage gauge measurements
  - instrument malfunction
  - type of sample collected (rain, snow, hail, etc)
  - contaminants (insects, leaves, etc)
  - operator comments

- procedures have been developed for transferring samples from leaking bags to new bags that avoid contamination

- samples are immediately shipped to (or picked up by) the regional technician, in containers that provide refrigeration and mechanical support

- the regional technicians are responsible for screening and documenting all samples from their regions. The duties include:
  - assigning sample submission numbers
  - repairing leaking bags
  - documenting all sampling information from operator field sheets
  - shipping samples to a central clearing house in Toronto
  - maintaining shipping log book
  - calculating precipitation amount from storage gauge measurements

4.1.3 Audit Results

The review of the procedures described above indicated that the present operating system provides a solid basis for the collection of representative, cumulative precipitation samples. The changes to instrument configuration are positive steps towards improving sample integrity, and the sampling procedures described handling methods that, if followed, should lead to the collection of contamination-free samples.

During the course of the audits, however, there were some areas in which shortcomings in the system, or the execution of the system were identified. Some of these areas are discussed below:

4.1.3.1 Audit Results - Operators and Technicians

The operators employed in the programme were found to be conscientious and concerned about their duties, and generally followed good sampling and data handling procedures. The major problems observed with the operators' sampling and handling procedures were a result of inadequate training and a poor understanding of why certain precautions or procedures should be taken. This shortage of operator training and education was observed in many areas of the sampling programme and is discussed along with documentation requirements in detail in section 4.4 below. The details of the operator checks carried out during the audits are presented in Appendix II and the results at the individual sites are presented in Appendix V on a site by site basis. Some of the more common and more serious operator problems are discussed below.

i) Sample Handling - during the sample changing process, many of the operators seemed unaware of the reasons for wearing disposable gloves (i.e. to allow only clean surfaces to contact surfaces that will touch the sample). Several operators were observed wearing only one pair of gloves to carry out all procedures; this included instrument cleaning followed by placing their hand inside the bag to smooth it against the collector surface. This obviously could lead to contaminated samples. These procedures should be more clearly explained and perhaps simplified in the documentation. A short list of sample handling procedures that could be posted on the sampler would be helpful.

ii) Sample Preparation - the bag inserts were often improperly installed, resulting in a distorted collector area and potential sample loss. The procedures for installing the bags should be carefully evaluated (simplified if possible) and the operators should be retrained.

iii) Sample Collection - operators were observed changing samples at incorrect times or on wrong days. In some cases this was not properly documented on the sample submission sheets.

iv) Instrument Checks and Cleaning - many of the operators did not perform some (or all) of the instrument and cleaning checks described in the procedures.

v) Storage Gauge - readings were often taken incorrectly.

vi) Log Books - the importance of detailed log books should be stressed to the operators. Some operators kept detailed log books including when events occurred, instrument problems, all sampling information; whereas others simply recorded dates samples were collected.

vii) Feedback and Information - almost all operators indicated a desire to obtain more information and feedback about the programme. In some areas the regional technicians provided information such as MOE publications and newspaper clippings that the operators found informative. Some of the typical comments were:

"How bad is the acid rain at my site?"

or

"How does the deposition at this site compare to others?"

The Regional technicians are responsible for maintaining the link between the individual operators and the APIOS programme. They are responsbile for maintaining the sites and inventory of supplies as well as training and assisting the operators. To carry out these duties it is important that they maintain close communication with the operators.

In some regions there are sites at which the frequency of visits is very low (i.e. every few months) due to travel restraints. Another problem is that the technician may visit the sites but not speak directly with the operator.

It is recommended that the technicians try to visit all sites on a regular basis (a minimum of every 2 months) and should try to observe the operator's handling procedures whenever possible. In several cases the audits revealed that site or operator problems may have been the result of the low frequency of technician visits and that more frequent instrument checks and discussions with operators would have been helpful. The frequencies of technician visits to the cumulative sites are summarized in Table 16.

The information recorded in the sample log books varied widely between the sites. In general the occurrence of events (time, duration and amount) was not recorded. This information would prove useful in data analysis and validation - particularly in determining the relative value of the samples during periods in which instrument failures occurred.

In the present system the information on sampling or instrumentation characteristics contained in the log books is not used in the data validation or interpretation procedures. A system should be developed that will allow this information to be evaluated and appropriate steps taken towards data validation. One such system would be to use a carbon copy log book system in which all information recorded in the log book is passed on to the QA co-ordinator.

4.1.3.2 Audit Results for Instrumentation

The Sangamo and MIC collectors used in the cumulative monitoring network have been employed by the APIOS programme for several years and are therefore very familiar to the staff and technicians. The instrument modifications that have been implemented indicate that a number of short-comings have been identified and corrected to enhance the sampler performance and collection characteristics. In general the APIOS support staff in Toronto are responsible for the initial set up and calibration of the monitors and the regional technicians are responsible for instrument maintenance and repair.

The audits carried out to evaluate instrument configuration and operation included a number of specific tests and general observations about the instruments and sites. The specifics of these tests are presented in Appendix II. They are briefly summarized below and presented in Tables 17 to 20. The site specific details are presented with the site evaluation summaries in Appendix VI.

1) Instrument Installation and Configuration

In general the precipitation samplers were installed such that the samplers were level and the orifice was at approximately 2 m above the ground. In some cases (eg. Milton) however, the collection bucket itself was not properly supported resulting in a non level bucket and improper gasket seal.

The nuisance tripping of ground fault circuit breakers (GFIC) was found to be a significant problem at some sites. This problem becomes more apparent when the circuit breakers are not readily accessible to the operator or technician. This circuit breaker problem occurs as a result of installing the GFIC breaker too far away from the sampler, which allows current leakage in the long power supply line and false tripping.

It is therefore recommended that the ground fault protection of these devices be as close to the sampler as possible (i.e. in the receptacle) and that the operator and technician have access to the breakers.

The installations of the precipitation storage gauges were also found to be highly variable. Several of them were not level and the height above ground (or snow) was not standardized.

Other tests in the configuration checks included gasket sealing ability, bag fit, gap in knife edge collar, and orifice size of samplers and storage gauges. These were generally as specified in the documentation with exceptions as noted in Tables 17 to 20 and Appendix VI.

Some additional problems that were noted with respect to the Sangamo/MIC collector configuration were a result of the installation of supplementary equipment at the site. One particular problem was the installation of the air sampling sampler filter heads at some of the Northwestern Region sites. At these sites the filter pack and (weatherproof cover) assemblies for the air samplers were installed on the sampling platform about 40 cm from the dry side bucket (Figure 7). This results in potential interference to the Sangamo sampling by the air sampler since the Sangamo sample container is in the shadow of the low vol hood. The air sampler instrument boxes were also often placed on the Sangamo sampling platform which reduced the space available on the stand and often hindered the operator during sample changes. Consideration should be given to constructing separate support stands and shelters for the low vol sampler equipment to avoid interference with the precipitation samplers.

2) Reasons For Instrument Failure

Based on discussions with network technicians and the auditor's previous experience, there are several common reasons for failure of the Sangamo/MIC collectors that result in lost or invalid data. These problems and discussions for prevention and service are discussed below.

a) Limit Switch Failure

Limit switch failure occurs as a result of deformation or damage to the limit switch because of improper adjustment of the screw that contacts the plunger on the switcn, or overtravel of the sampler activation arm. Failure of the limit switch results in immobilization of the sampler lid in either the wet or dry position and thus an invalid sample.

b) Heater Failure

Failure of the heating circuit on the sensor grid occurs as a result of a failure of a component on the instrument's printed circuit board or a failure of the sensor grid heater element. This results in the sensor grid not being heated and thus incorrect activation of the sampler lid. During the winter, the samplers may not activate for snow (since the snow would not melt or stick to the grid) and during the summer the sampler would remain open for an extended period because the accumulated precipitation would not evaporate quickly. Both of these conditions result in the collection of non representative data.

c) Fuse Failure

Failure of the internal instrument fuse often occurs as a result of shorting of the power supply by either condensation within the instrument, or failure of components on the printed circuit board. Other causes include failure of limit switches resulting in motor overheating and power surges in the supply line. These failures result in the total immobilization of the sampler, and therefore no collection of sample.

d) Motor Failure

Motor failure can occur as a result of "motor run on" (in which the motor tries to continue moving after the lid has stopped) or a failure of the grease plugs. These problems render the sampler immobile and result in lost data.

e) Sampler Arm Slippage

The sampler arm is often found to be moving erratically ("flopping" from one side to another) or slipping completely and not moving the sampler lid. These faults, which occur as a result of failure of the expansion pin connection on the drive shaft or slippage of the torque limiter, can lead to complete instrument failure (motor burn out) and potential sample contamination as a result of the violent action of the lid striking the bucket.

f) Faulty Tripping of Circuit Breaker

Faulty tripping of a circuit breaker is often the cause for lost data. When the circuit trips, the power is off and the instrument no longer functions. Some of the causes for this faulty tripping have been described above.

3) Sangamo Sensitivity

The sensitivity of the response of the Sangamo is set during instrument preconditioning by the use of a sensor grid with a standard resistance (220 KΩ). During the audits the sensitivity of sampler response was calibrated by shorting the sensor grid with a variable resistor of known value. The resistances at which the samplers were activated were recorded and are presented in Tables 17-20. These results indicate that the sensitivity of response of the Sangamo varied from 50-400 KΩ indicating a large amount of scatter. The relationship between this resistance and the sampler sensitivity in terms of precipitation type or amount, however, is not clear.

4) Condition of Sensor Grid

The condition of the sensor grids was checked by visual inspection and an assessment of whether or not the grid was warm. In questionable cases the sensor heating was checked by monitoring the current input to the heater. The sensor grids were generally in good condition. However, in some cases the boards were burnt out, or did not respond as indicated in Tables 17 to 20.

5) Hood Movement and Clutch Adjustment

The APIOS documentation indicates that the sampler hood should move smoothly from the wet to dry side pail and that the clutch on the hood drive sprocket should be adjusted to about 14 foot-lbs pressure to ensure complete gasket sealing but not stress the limit switches. The clutch pressure was measured by using a small spring scale (with a maximum capacity of 28 lbs to determine at what point the clutch started to slip. In several cases the clutch adjustments were so tight that the clutch could not be forced to slip. In these cases if the sampler is improperly adjusted there may have been significant stress on the limit switches which could lead to premature instrument failure. Erratic hood movement was also noted in several cases indicating improper chain and sprocket adjustment.

The condition of the limit switches was also checked, and found to be satisfactory for most instruments.

6) Hood Return Delay Time

The delay time for the sampler hood return should be set at 90 seconds. This was monitored by simply activating the sampler and determining the time required for the lid to return. The delay times observed were generally with in ± 20 seconds of the proper setting.

7) Calibration and Maintenance Procedures

At the beginning of the audit programmes, the instrument service and maintenance was carried out by the technicians on an "as needed" basis relying on the experience of the technicians to spot wear in the instruments and to decide when to perform service. The policy for instrument repair was that each regional technician should have a spare instrument to replace the one taken in for service. Early in the audit programme it was realized that more formal, scheduled procedures were required for routine service and maintenance. As of the fall of the 1982, regularly scheduled instrument checks and preventative maintenance procedures are being employed. The important areas covered during the routine maintenance and instrument checks are summarized below:

a) Instrument Checks during each visit

- limit switch adjustment
- clutch adjustment
- chain and sprocket alignment
- hood delay time
- motor
- gasket condition
- cleanliness of instrument
- check storage gauge solution and level
- check sensor grids
- check power supply - breaker and wiring condition

b) Regularly Scheduled Service

- replace limit switches and check adjustment screws every 6 months or as required
- adjust sampler sensitivity and delay time every visit
- check motor - particularly grease plugs and repair as necessary
- check P.C. boards regularly (every six months for pin condition, contacts etc.)

This service and maintenance schedule has been documented and distributed to all technicians. In future this documentation should be expanded to include more specific checks and tests including:

- testing of individual components on the P.C. boards
- checks for and prevention of condensation within the instrument housing
- ensuring that sensor grid thermistor and heater grid element are completely encapsulated in epoxy - clean pin contacts every 6 months
- check all wire leads inside instrument for change and corroded contacts
- check transformer output (12.6 - 15 V A.C.) since variable output can affect P.C. board performance

Detailed instrument log books should also be used to record the specific information (checklist format) and the results for all samplers should be monitored (by the technical co-ordinator) to assess and report on sampler performance.

4.3.1.3 Sample Shipment and Storage

Sample shipping and storage procedures have been developed to ensure that the cumulative precipitation samples (and air sampling filters) are processed as quickly as possible. Care is taken to avoid shipping procedures that expose the fragile samples to careless handling or potential contamination. In general the samples are picked up by the technician shortly after the end of the sampling period. The samples are usually refrigerated between collection and pick up. The samples are then taken (refrigerated during shipment) to the regional office for sample processing, packaging, and subsequent shipment to the central office, and to the laboratory for analysis. In some of the more remote areas in which the technician is not able to visit all sites at the end of the sampling period, the samples are packaged and shipped by commercial carriers. These procedures usually result in submission of the cumulative samples to the laboratory within about 1-3 weeks after collection depending on the site location.

During the audit programme the sampling storage and shipping procedures employed by various members of the programme were observed to ensure that appropriate measures were taken to maintain sample integrity during shipping. Discussions with various personnel (operators, technicians and laboratory staff) indicated that in spite of these precautions, the sample bags were often found to have leaked by the time they reached the laboratory. In some cases a considerable amount of sample was lost through pinhole leaks. Until these problems with leaking bags are eliminated, it is recommended that the sample volume be determined as early in the sample handling chain as possible, and the volume measured in the lab be used as a quality control check. The leaking bags also present a potential sample contamination problem if it is possible for the sample to re-enter the sample bag after being exposed to the outside of other bags, or sample leaked from other bags.

The timing of sample custody was investigated through discussions with regional technicians, staff in the central office and tracing actual samples through the shipping procedures. The typical time for the sample to reach the laboratory was 1-2 weeks for southern regions and 2-4 weeks for northern regions. The sample custody timing observed for specific sites during summer and winter are summarized in Table 21. This table indicates that the times for shipment do not vary much from summer to winter, however it often takes longer for the sample analysis to be completed during the summer when the laboratory is busiest.

4.1.3.4 Other Factors Affecting Cumulative Samples

A number of areas that affected the quality of the samples or data collected could not be categorized into the sections above. These areas are discussed below:

1) Dry Side Sampling

The use of the dry side bucket to collect dry deposited material is of questionable merit. It is well known that the open bucket does not collect a sample representative of dry deposition to the environment. Furthermore the dry side sampling appears to be a potential contamination source for the wet side sample. This potential contamination arises from the fact the polyethylene bag insert in the dry side bucket often protrudes above the upper surface of the bucket and collects dry deposited material. When the sampler lid moves from the wet to dry bucket at the beginning of an event, the gasket surface of the lid "smears" the protruding portion of the bag across a relatively large area of the gasket - picking up dry deposited material from the dry bag on the wet portion of the gasket. Upon completion of the event, the lid moves back over and seals the wet side. The contamination from the dry side is then free to enter into the precipitation sample either by recirculation (evaporation followed by condensation onto the lid) or gravity.

If the dry side measurements are deemed necessary, consideration should be given to preventing the gasket from contacting the contaminated dry side bag.

2. Knife Edge

The knife edge collar modification to the Sangamo sampler has been incorporated to improve the sampler aerodynamics, improve the gasket seal and reduce sample contamination. These collar rings are designed to hold the bag in place by fitting over the outside of the sample bucket. In order to facilitate the installation of these collars, they have been split. These collars fit reasonably well (slight gap in the ring) over the summer buckets, however, the bucket used for winter time sampling has a significantly larger outside diameter resulting in a large (up to 2 cm) gap in the ring. This gap may result in lost sample due to evaporation (particularly on hot, sunny days) and is a potential contamination source of particulates entering the sample vessel.

This could be reduced through modification of the knife edge sample container.

3. Polyethylene Bag Inserts

The use of polyethylene bags as pristine sampling containers is an excellent idea. There are, however, some areas of concern that should be noted. It is often difficult for the operators to install the bags properly. Often the bag cannot be pushed to the bottom of the container (particularly in the winter) and folds form in the bag. These folds are of particular concern when they are near the top of the sample container and may influence the collection characteristics (in some cases the bags were actually as high as the knife edge) or provide a "shoulder" for the precipitation to sit on and then subsequently be blown away. This problem is particularly important for the dry side bag since the wet side bag has the weight of the collected sample pulling the bag down after a short time. In the past, the problem has been partially avoided by placing a weight on the outside of the bag to hold it in place in the vessel. This practice, however, has currently been eliminated to simplify the bag installation procedures.

Another problem with the sampling bags is the problem of leaking. As many as 50 % of the cumulative samples collected from a given site during the winter are found to have small "pinhole" leaks as a result of stresses on the bag due to bag freezing or the bag sticking in the container as it is removed. Procedures have been developed for sealing these leaks, but they are not always successful, as the leaks are hard to identify and often only appear as the frozen samples begin to melt.

5. Storage Gauge

The configuration of the precipation storage gauges was found to be highly variable between sites. The operating procedures state that stands should be used in the winter to keep them above the snow pack and they should be leveled on the ground during the summer. In practice, however, the gauges were found not to be level and at various heights. In some cases the technicians reported that they were actually buried in the snow.

The procedures for making the storage gauge measurement are often difficult to follow. It is difficult to measure the gauge depth using the "dipstick" procedure outlined in the existing procedures since the covering oil layer often does not leave a distinct mark on the dipstick. In addition, when the gauge is not level there can be a significant discrepancy in the depth obtained depending on where the measurement was taken.

The use of the storage gauge to determine precipitation amount during the winter is also questionable since it suffers from the same aerodynamic shortcomings (with respect to snow collection) as the Sangamo and other unshielded gauges. This is of particular concern in some of the more wide open sampling sites with limited windbreak.

All of the concerns about the storage gauge are of extreme importance since the storage gauge information is used to provide the precipitation depth measurement for use in deposition and efficiency calculations. Errors in this measurement are therefore as important as errors in chemical analysis.

4.1.4 Recommendations Regarding Cumulative Precipitation Sampling

As a result of the audits of the cumulative precipitation sampling programme the following recommendations are presented:

1. The sample handling procedures should be re-evaluated and documented to provide the simplest possible procedures. The operators should then be trained on the new methods and checked frequently to ensure proper techniques are being observed.

2. The regional technicians should visit the sites as often as possible (at least every two months) to perform operator training and instrument service.

3. Instrument and site log books should be redesigned to ensure that all relevant information is passed to the QA coordinator so that it may be used for data validation and interpretation.

4. The analysis of the dry side bucket sampling should be reconsidered. Considerable expense and effort is expended in the collection of these samples that are of marginal (at best) use. If continued, the potential problem of contamination of the wet side sample should be eliminated.

5. The sampler configuration and preventive maintenance checks should be expanded and documented in formalized procedures and schedules. The performance of these checks should be verified by the network co-ordinator.

6. Continued design work is required with respect to the modifications to the Sangamo/MIC sampler. The following areas should be addressed.

   - a knife edge collar should be designed for the winter buckets to eliminate the gap problem

   - a system should be designed to improve bag fit by pulling the bag down into the bucket and forming a proper shape at the orifice

   - the cause and prevention of leaks in the bags should be investigated. Until a solution is found the sample volume should be determined in the field and the sample bags should not be used as the sole shipping container.

7. The storage gauge measurement for precipitation amount determination should be evaluated. In particular, a new method should be developed for determining the depth. The collection efficiency during winter should be investigated, and more attention should be paid to standardizing the gauge height and

ensuring that is level. Co-located storage gauges should be employed at a number of sites to examine the precision of the storage gauges and measurement techniques.

4.2 Event Precipitation Sampling Procedures

4.2.1 Instrumentation

The event precipitation monitoring programme employs two different types of samplers during the summer and winter seasons. During the summer sampling the Aerochem Metrics wet/dry sampler is used to collect precipitation samples in polyethylene bags on a daily basis. In the past, the samples were collected in the Aerochem Metrics buckets directly. However, the network changed to bag inserts (Spring 1982) for the reasons discussed above under cumulative sampling.

During the winter the Aerochem Metric sampler is not used due to its poor sample collection efficiency for snow. It is replaced by the SES type bulk collector which is simply a large mouth collector vessel with a polyethylene bag insert. The bags are changed daily. The samples collected therefore consist of event wet-only samples during the summer, and daily bulk (wet and dry) samples during the winter.

The fact that the SES sampler collects a daily bulk sample rather than a wet-only sample means that careful attention must be given to the siting criteria discussed in Section 3 above. The nature of the bulk collector makes it very susceptible to wind blown contaminants and thus ground cover and potential dry contamination sources are of extreme importance.

The precipitation amount for the event sampling is also measured on an event basis. In the summer, a standard rain gauge is used, while the nipher shielded gauge is used during the winter.

4.2.2 Sample Handling Procedures

The operators employed in the event network generally have similar backgrounds to those in the cumulative monitoring programmes and thus similar sample handling procedures have been developed to ensure that sample integrity is maintained. In general, the basic concepts for the event sample handling are the same as those of the cumulative network that were discussed in detail Section 4.1.2 above. Some of the more important differences in the two types of samples are discussed below.

Event samples are actually precipitation samples collected over a 24 hour period. Samples are collected daily at about 0800 hrs local time. The general procedures for sample preparation are similar to the cumulative programme in that:

- new, unused polyethylene bags are used to collect the samples
- only the outside of the bags should be handled and clean disposable gloves should be worn when doing so
- the bag should be installed so that the bag fits the orifice shape properly
- bags should be removed in such a way that no potential contamination occurs

Once the sample is collected, it is immediately transferred to a polystyrene bottle, labelled and stored under refrigeration (refrigerators have been provided by APIOS as required) until it is picked up by (or delivered to) the regional technicians. Detailed procedures have been developed and documented to describe the sample transfer process and to ensure that no potential contamination is introduced.

The data recording system consists of operator data sheets that are used to record the sampling information and the associated standard precipitation gauge measurements. The information recorded includes event type, amount (standard gauge) and time of event.

The use of the standard rain gauge (summer) and nipher shielded snow gauge (winter) is well documented in the network documentation. Specific instructions are provided for their installation and operation.

The technicians are responsible for picking up the samples on a weekly basis. During the visit to the sites the technicians check and clean all instrumentation, check the operator log books and discuss any problems or unusual events with the operators.

The technicians then take the samples to the regional laboratories to determine the sample volume (by weight) and measure the "field" pH. The procedures for pH measurement have been standardized across the network, however no audits of the pH measurement are routinely performed. No pH determination is done for the Northwestern Region samples, because it often takes several weeks for the event samples to be collected, and a "field" pH after that period would have less meaning.

The samples are then shipped under refrigeration to the central office for logging and submission to the laboratory.

4.2.3 Audit Results for Event Precipitation Sampling

The audit questionnaires used to carry out the detailed audits of the event precipitation monitoring sites, operators, and instruments are presented in Appendix IV. The details of the results of the individual site visits are presented in Appendix VI.

In general, many of the results and recommendations determined in the cumulative monitoring audits are also valid for the event precipitation programme and are not discussed in detail in this section. These common areas are summarized and the areas specific to the event network are discussed in more detail.

4.2.3.1 Operators and Technicians

In general, the operators in the event network were found to employ proper sample handling procedures in the preparation and collection of samples. The instruments and sites were generally well maintained and the information documented in the log books and sample forms was correct and reasonably complete. As in the case of the cumulative network, the majority of the sample preparation and handling errors and incompleted data recording problems were a result of ignorance and a lack of training. In addition to the specific sample handling problem areas noted above (improper sample times, poor handling and cleaning practices and improper information recording at isolated sites) the following areas specific to event sampling were noted:

- sample submission sheets were often not submitted for small events. The importance of reporting this data should be stressed

- operators tended to put their hands into the sampling containers in attempting to improve the bag fit. In some cases this may have resulted in contamination of the bags

- the sample volume is determined by the technician by weighing the sample bottles and subtracting the tare weight. The value for this tare weight should be re-evaluated periodically - particularly when new batches of bottles are obtained

- the length of time between sample collection and "field" pH measurement varies considerably. In many cases it is not reported at all. The importance of this measurement should be determined, and time limits established for carrying it out

- many of the event bottles used have been observed to have flaws in the bottle itself and in some cases foreign material (cardboard) inside the bottle. These bottles should be carefully inspected prior to use. In some cases the bottle lids do not seal properly resulting in sample loss. The white plastic lids were found to be particularly bad for this.

4.2.3.2 Instrumentation

1) The configuration of the SES samplers (Table 22) was reasonably consistent from site to site (~ 1.5 m above ground, orifice size 45 cm diameter) however the orifice was often out of round. In some cases the SES collectors were not level. The fit of the bag in the SES sampler was generally observed to be

quite good, however, in some cases the bag actually extended above the rim of the collector. The rim on the sample container also presented a minor problem since snow accumulated on it and operators were unsure of whether that snow should be included in the sample or discarded.

The samples collected by the SES sampler were observed to be contaminated by windblown particulates much more often than other samplers.

2) Aerochem Metrics Samplers

The samplers were generally installed and operated in the same configuration (Table 23). The height above the ground was also constant. Only one sensor grid failure (did not heat up) was observed.

The sample collection bags used for the Aerochem Metric sampler did not seem to be the proper size. In all cases, poor bag fit was observed, resulting in distorted orifice shape and potential sample loss. The gasket seal on the underside of the sampler hood was generally in good shape, although there were some individual cases of deterioration.

Some general comments by the operators indicated that in many cases the Aerochem metrics samplers took up to several hours for the hood to return after an event had stopped.

3) Nipher Snow Gauge Configuration

A number of potential problem areas were noted in the case of the nipher gauge measurement for precipitation depth during winter. The stands built to support the niphers were poorly designed. Several operators commented on the dangers of using this stand under poor sampling conditions.

The height of the nipher shield (Table 24) was not adjustable. Therefore no compensation was possible for changing snow pack depths.

The network procedures provide two separate collection vessels for use in the nipher shield so that one can be used to allow the sample to melt, while the other is sampling. These collection vessels have no lids, therefore, it is possible that a considerable amount of precipitation "depth" is lost (by evaporation) when samples are allowed to melt (often indoors at room temperature).

In some cases the collection vessel inside the nipher gauge did not fit well and the top of the collection vessel actually sat slightly above the shield. This undoubtably affects the collection efficiency of the nipher gauges.

4) Standard Rain Gauges

The standard rain gauges were often found to be dirty and installed at varying heights above ground (Table 25). The ground surface cover was also found to vary in height around the gauge.

4.2.4 Summary and Recommendations - Event Precipitation Sampling

The event precipitation monitoring programme of the APIOS network was found to employ basically sound sample collection and handling techniques. A detailed set of operating instructions have been provided that describe handling methods that should lead to the collection of representative, contamination free samples. The operators generally collected, processed and stored the samples according to the documented procedures, however, in a few cases, specific problem areas were noted.

The instrumentation used in the monitoring of event precipitation is generally quite simple and straightforward. The configuration of some types of monitoring equipment was found to be quite variable in some cases.

The sampling information collected was generally well documented. The network procedures provide a mechanism for the recording and transmittal of complete sampling information. Some specific operators however, did not provide all of the information required.

A number of recommendations have been generated as a result of these audits of the event precipitation monitoring programme and its associated QC/QA programmes. These recommendations should be considered during the continued implementation of network quality assurance procedures.

1) A new documentation package should be prepared to describe the sampling procedures. Many operators did not have documentation or, the documentation was out of date.

2) The configuration of all instrumentation should be standardized across the network. In particular, the height of the orifices above the ground should be standardized for all collectors and gauges.

3) The nipher gauge sampler should be evaluated. The stand should be redesigned for safety and height adjustment (if desired). Caps should be considered for use in melting the collected samples at room temperature.

4) The response characteristics of the Aerochem Metrics sensor should be evaluated. The long time often observed for the hood to return after an event should be investigated and cor-

rected if possible. The bags used in the Aerochem Metric sampler should also be evaluated. It is difficult to install the bag in a proper fashion which results in folds in the bag near the orifice. This can seriously affect performance.

5) Precision studies for the precipitation depth measurement (nipher and standard gauges) should be considered since the precipitation depth measurement is a very important parameter in the deposition calculations. These gauges should also be routinely calibrated as part of routine QA/QC.

6) The requirements for the measurement of "field" pH should be evaluated. If this is an important parameter, steps should be taken to ensure that it is done for all samples and the timing for the measurement should be established.

4.3 Air Sampling Procedures

4.3.1 Operating Procedures

The daily and cumulative air sampling monitoring programmes employ multi-stage filter pack sampling assemblies to collect air samples for subsequent laboratory determinations of the air concentration of various atmospheric pollutants. In each case a prefilter is used to trap particulate material followed by a nylon filter for gaseous nitric acid and an impregnated cellulose filter for capture of gaseous SO_2.

The samplers themselves consist of a pump, flow monitoring systems and a clock or timer.

The basic operating and sample handling procedures for the two types of air sampling systems are similar. The major differences in the programmes are summarized below:

- The cumulative sampling filter pack employs a cellulose (Whatman 40) filter to trap particulates whereas the daily uses a Teflon prefilter.

- The daily air sampling is done with a sequential sampling device that samples at about 25 l/min for 24 hrs before automatically switching to the next sampling port. Seven ports are available for sampling, thereby allowing a week of unattended service. The flows for each sampling day are recorded by dry gas meter readings for each port.

  The cumulative sampler employs a single port sampler to collect a 28 day sample at about 2.0 l/min. The flow is also monitored with a dry gas meter.

- The daily air samples are collected at a height of 10 m. The cumulative samples are collected at ~ 2 m above the ground.

- The daily air sample filter packs are exposed for 6 days in which they do not sample. They must therefore be corrected for passive sampling by exposing a passive sample for the entire week and subtracting the passive value from the active results. No such correction is required for the cumulative samples since they are sampling continuously for the entire time they are exposed.

- The daily air sampling instrumentation is generally operated by skilled MOE staff, whereas the cumulative samples are collected by local operators. All filter handling (loading and unloading) is done by the regional technicians.

The sample preparation and handling procedures to be used for the air sampling networks have been well established by the APIOS programme through their use in other related programmes. The sample preparation procedures that have been developed are well documented and describe the precise handling procedures that should be followed to ensure that no filter contamination occurs. The important steps that are included in these procedures include:

- the preparation (impregnating, etc), cutting and packaging of filters
- filter pack washing and loading procedures
- installation of filter packs in sampling device
- sampler configuration checks before and during operation
- sample removal and filter pack unloading
- sample shipment and data recording

4.3.2 Audit Results - Air Sampling Programmes

The documentation describing all of these procedures was not available at the beginning of the audit programmes, however, it has now been generated and distributed to all appropriate members of the programme.

These procedures were generally followed for all stages of the air sampling programme. No evidence of significant deviations from the sampling procedures were observed in filter preparation, loading and unloading filter packs or instrument operation. Each of the technicians, however had a slightly different procedure for loading and un loading packs. In each case the handling procedures were adequate to avoid sample contamination, but some methods were faster and more efficient than others. Some of the differences included the order in which filters were removed, the cleaning of filter handling equipment, and storage of cleaning solutions.

One potential area of concern that was noted was the sampling handling facilities available to the technician. In general these consisted of clean rooms or areas in laboratories but in one instance (Southeastern Region) the samples were changed on a desk top in an office. The storage of the cleaning solution in this case was also questionable, since the beakers containing the rinse solution and tweezers were stored uncovered on a shelf exposed to the normal room air.

Procedures for regular preventive maintenance have also been provided for the air sampling equipment. The historical practice of waiting for failure before servicing has been abandoned for regularly scheduled maintenance including:

- meter checks·
- flow adjustments
- pump overhaul
- cleaning as required

The QC/QA procedures observed as part of routine procedures consisted of routine analysis of unexposed filters after preparation. Several sample filters of each type (W40, W41, nylon and Teflon) are submitted to the laboratory for analysis before a set of filters is sent to the field. The results are immediately analyzed to ensure that contaminated filters do not get into the sampling system. In the past, blank filters were also periodically returned from the field for blank analysis. No significant contamination problems have been observed in either case.

QA/QC procedures were lacking for the calibration and pretesting of many of the air samplers. The sequential devices for daily sampling were calibrated (rotometer and totalizer) prior to installation (September 1980), but have not been recalibrated since. Many of the cumulative, low volume samplers were not calibrated at all prior to installation, since they were rushed into the field to meet a sampling start-up-date. In addition, the calibration factors that were calculated do not seem to be applied to the volume measurements recorded as part of the sampling information data.

The procedures used to check the air samplers during the audits are presented in Appendix II and IV for the cumulative and daily air sampling procedures respectively.

The results of the low volume air sampler configuration checks are presented in Table 26 and may be summarized as follows:

- The sampling height was consistent at 1.5 - 2.0 m above ground.
- The rotometers were in good condition, but no calibration factors were noted.
- The samplers did not have shelters. Many were enclosed in plastic bags or left open to the elements.
- Many operators had difficulty installing the filter pack onto the sampling device. The fitting was tight and access was difficult.
- The in-line calibrations of flow totalizer against mass flow meters that were traceable to primary standards generally

revealed less than about 10% deviation. In some cases however the deviation was of the order of 20%.

- No leaks were observed in the low volume sampler apparatus.

Audit checks of the daily sequential sampling instrumentation were also carried out to investigate the sampler configuration. Some of the areas noted include:

- The operators generally had difficulty with the "press-fit" seal of the filter packs to the sampling head. Some of the 'O' ring seals were also in poor condition.
- Filters were generally changed according to proper procedures - the sampling head did not rest on the ground.
- The sampler boom at the Charleston Lake site was damaged.
- The total flow calibrations (single channel so that regular sampling was not disturbed) were generally within ±10% of the flowmeter flow.
- No leaks were observed in the sampling train or between channels.

One of the sequential sampling devices was also made available for detailed laboratory testing. This instrument (Longwoods) was found to be in good condition with the exception of some minor wear items (pump diaphragm, difficult connections, dirty pump filter). The seven channels of the sampler were tested, and no leaks or cross sampling were observed. The gas meter registered between 97-103% of the mass flow meter sampling rate.

4.3.3 Recommendations

The following recommendations are presented with respect to the air sampling programmes:

1) The filter handling (loading and unloading) procedures should be standardized to ensure all technicians handle filters in the same fashion. The submission of field handling blanks should be reinstated as part of routine QC procedures. The field handling blanks should undergo all filter handling procedures at sample change over.

2) Duplicate air sampling should be carried out at a minimum of one location for each type of sampling to provide a measurement of precision.

3) The use of passive filters for the correction of daily air sampling filters should be examined. The statistics of variability observed within passive values would be a useful.

parameter. Elimination of the necessity for the passive sampling correction should also be considered. This may be possible by the use of a carousel type arrangement in which the filters are exposed only when sampling.

4) The volume measurement on all air sampling equipment should be calibrated on a regular basis (at least twice per year) and the calibration factor should be applied to the raw volume data before reporting.

5) Shelters should be constructed for the cumulative low volume samplers.

4.4 General Network Operations

4.4.1 Network Documentation

The systems audit for network operations required that the documentation for the various portions of the monitoring programme be examined for correctness and completeness. During the preliminary network review and planning stages of the audit, it became apparent that much of the network documentation was either not available or out of date. The documents that did exist for the event and cumulative precipitation monitoring networks consisted of documents describing network start-up and monitoring objectives. Many of the sample and data handling procedures described in these documents were incomplete and out of date and did not describe the operating procedures used in the field.

The correct operating procedures for the various monitoring programmes (event and cumulative precipitation monitoring and daily and monthly air sampling) were therefore identified through these documents and consultation with APIOS personnel. The existing documentation was then revised and edited to provide specific procedures for all phases of the sampling operation. These documents were then reviewed by APIOS personnel to ensure that the auditors had what were considered to be "current operating procedures". The editing and reorganization of the network operating procedures should not have been carried out by the auditors. However, this was deemed to be the most practical method of generating a structured set of network procedures on which to base the performance audits. The documented procedures produced as a result of this reorganization were presented in the preliminary audit report (5).

It is important that proper documentation be available to all members of the monitoring program including operators, regional technicians, QA personnel, network managers and data analysts.

It is therefore recommended that the operational procedures for all areas of the APIOS programme be documented in a systematic fashion to ensure proper sample and data handling procedures by all members of the programme. The documentation package should be organized so that specific areas of the procedures are readily identified and can be distributed. A document control system should also be implemented to permit updating or modification to the existing procedures as required. A suitable document control system has been described in many QA/QC documents including the USEPA Quality Assurance manual (16). The important features of the document control system are:

- a distribution system so that documents get to all appropriate members of the programme

- a detailed table of contents

- a method of ensuring that changes or modifications are incorporated by all personnel.

In addition to the standard operating procedures, the documentation package should include the routine QC steps that should be taken at all stages of the programme to ensure that they are carried out as part of normal operations. For example, the procedures for the operator to include routine split or duplicate samples should be included as part of his routine sampling procedures.

The documentation package should include the following areas of the programme:

- description of the document control system
- network descriptions
- organizational chart and duties

- detailed sampling procedures for all networks
- data validation and reporting
- sample analysis
- reporting

4.4.2 Network Monitoring Structure

During the course of the audit programme, the interviews and visits with various members of the APIOS monitoring programme indicated that the existing network structure provided a good basis for the collection of quality data. The programme structure consists of sample collection across the province supervised on a regional basis by the five regional technicians. These technicians in turn are supervised and supported by a central office.

This structure leads to the development of good operator supervision as a result of intense and consistent support by the technician. The strong central office provides a means of ensuring consistency across all regions, allowing for the implementation and monitoring of a strong quality control and quality assurance programme.

The fact that all laboratory analyses are carried out at one laboratory, with a strong QA/QC programme, is also a good feature. It ensures that all sample analyses are performed in the same manner and have the same QA/QC procedures applied to them.

4.4.3 Training

The evaluation of the level of training within the APIOS programme revealed that the regional technicians were well trained in all areas of sampling and instrument service and repair. The relative levels of experience of the technicians, however, were obvious in many cases. The technician training has been undertaken throughout the programme by the use of periodic intensive technician training sessions as well as continued contact with the technical co-ordinators on a day to day basis.

In many cases however, the local field operators were poorly trained. It is the responsibility of the regional technicians to ensure that all operators in his region follow correct sampling procedures. The technicians should ensure that the operator has the documentation required and should periodically review the procedures with the operator and observe the sample changes and point out problem areas that are noted. This must be done on a regular basis at all sites.

4.4.4 Inventory and Support

In general, the inventory and support systems for the field monitoring programmes were well established. The materials and supply requirements for all areas of operation are monitored by an inventory request system sent to the regions by the central office. An inventory is thus maintained in each region to support the local operators.

A technical support group has also been established at the central office to support instrument development, service, calibration and repair. This group is also responsible for carrying out a number of special studies designed to evaluate sampler characteristics and performance.

5.0 DATA HANDLING AND VALIDATION PROCEDURES

The audits of the data handling and validation procedures of the APIOS programme were carried out to document and evaluate the procedures used to generate and report the network data. The systems audit consisted of documenting the data transfer and handling procedures carried out in the field, at the central office and in the laboratory. These procedures were then examined to determine if they were sufficient to ensure the collection and reporting of quality data. The systems audit also consisted of a review of the status of the data collected by the various networks within the APIOS programme and documented typical times required for analysis and reporting. The data screening and validation procedures were also documented and reviewed as part of the systems audit.

The performance audits were used to evaluate whether or not the system was properly followed at all stages of the programme and if so, how well it was working. The performance audit consisted of interviewing various personnel at all stages of the programme and evaluating some historical data by comparing the original field sheets and laboratory analysis forms with the computerized data base.

This section does not discuss the laboratory data handling and analysis schemes except where they overlap with discussions on data base management. The details of the audits of laboratory data handling procedures are discussed in Section 6.

During the audit period, the data handling and validation procedures for many portions of the programme were under development. For much of the data, the laboratory analysis results were simply merged with the field data sheets and stored for subsequent screening and validation. As the audit progressed some of the data handling and validation procedures were developed or modified. In some cases these modifications were implemented as a result of preliminary observations and recommendations by the auditors.

The results of the systems and performance audits of various stages of the data handing validation and reporting procedures are described below.

5.1 Data Handling System

The various data processing and validation processes for the APIOS monitoring programme are presented in Figure 8 and are summarized below. These summaries consist of a description of the system used as well as an evaluation based on the audit results.

5.1.1 Operator Data Handling

The operator is responsible for collecting and labelling the samples and logging the appropriate sampling information on the operator field sheets. Separate field sheets are used for the event and cumulative precipitation sampling networks. Copies of the current versions of these sheets are presented in Figures 9 and 10 for the event and cumulative netowrks respectively. Operators at sites with cumulative low volume air sampling instrumentation are also responsible for documenting the flow and sampling time results for the low volume air samplers. In addition to the sampling information, the operators should also note any unusual characteristics about the sample (eg. contamination, instrument failure, unusual events etc.) with the various comment codes. The operator is also responsible for noting sampling information in his station log book. Information that should be recorded includes flow adjustments to low volume samplers, dates of instrument checks and cleaning, and other notable events.

The daily air sequential sampling information is generally completed by the regional technician. The important information recorded in this case consists of the volume sampled, the filter batch identification and the identification of the passive sample(s) associated with the set of filters.

In general, the audit visits revealed that the operators and technicians were properly labelling and documenting the samples collected. One major problem that was observed was in the reporting of trace or low volume precipitation events. In many cases when the amount of precipitation collected was not sufficient for analysis, no sample or field sheet was submitted. Since one of the major objectives of the event monitoring programme is to determine the frequency and intensity of precipitation events, it is important that a field sheet be completed anytime precipitation was observed in the standard precipitation gauges. Some other minor problems observed included poorly maintained log books and, in some cases, no record of flow adjustments to air samples and untimely recording of data. Some operators did not record the sampling information immediately which could lead to omissions or errors.

The data sheets used to record the sampling information must also be completely and consistently filled out. It is the responsibility of the regional technicians to ensure that all relevant data is passed through the system. Some general comments about the data sheets are presented below:

- Are two separate sheets (operator and technician) required? A single sheet partially completed by the operator then finished by the technician may eliminate data or transcription errors.

- Precipitation start and end times (for event samples) are subject to extreme variablity since operators are often not on site when the event occurs.

- Operator comments should be standardized. What is a light, heavy or medium event?

- Some operator comments do not translate easily to field comments (e.g. hydro failure).

5.1.2 Regional Technician Data Handling

The regional technician is responsible for processing the samples collected in his region. He should check the operator's log book to ensure that all relevant information is being recorded and transferred to the data sheets. The technician then carefully screens the samples and adds field comments as required. He is responsible for identifying the filter batch associated with the air samples. The technician also provides and records (on the field sheet) the field pH for event precipitation samples collected if sufficient sample is available. The technician then assigns field sample numbers to each sample (sequential numbers within each region) and fills out a field sampling data sheet. The samples and data sheets are then shipped to the central clearing house in Toronto for processing.

In general the technicians have set up good filing and sample tracking systems to record the information associated with each sample. This information has often proved useful in subsequent data validation or interpretation.

In the past, the technicians were responsible for completing a monthly sample summary form that was meant to summarize the sampling conditions and unusual events for the event and cumulative samples submitted each month. The use of this form however, has been suspended due to the amount of time that was required to complete it. It is recommended that the use of this type of summary be reintroduced to the monitoring programme since it can provide information that is very useful to the QA co-ordinator in determining the quality of the samples that are collected. These summaries need not be time consuming and the time taken to summarize the sampling conditions immediately after sample collection, is considerably less than that required to go back and look at the data several months later. This system would also introduce a means of getting the technical staff to be more aware of the quality of the samples they are shipping and become more involved with the data validation and reporting portions of the programme. Some of the information that would be useful in these types of summaries, includes:

- A brief summary of instrument or site related problems responsible for down time.
- A summary of when events occurred for cumulative samples.
- Evidence of or suspected contamination.
- Summary of precipitation gauge measurements.
- Summary of calibration or maintenance results.
- A summary of events sampled for the event network. This would be particularly helpful for identifying lost or incorrectly labelled samples (see section 5.4 below).
- Summary of unusual events in the past month.
- Schedule of activities for the [illegible] month.

These types of summaries should be provided to the QA co-ordinator on a regular basis so that he can spot problems or trends in the sampling data as they occur and implement corrective action procedures to prevent large amounts of lost or invalid data. Under the present system, the time delay between sample collection and data validation does not lead to immediate identification of these types of problems.

5.1.3 Data Entry Procedures

The data entry editing and validation procedures for the laboratory and central office of the programme are illustrated in Figures 11 and 12.

All samples and data sheets are sent to the head office in Toronto for cataloguing and submission to the laboratory. The samples are then logged and copies of the field data sheets are prepared for keypunching of the field sampling data.

As the samples are received at the lab, they are automatically queued into the Laboratory Information System (LIS) and data base and then routed to the appropriate work stations within the laboratory. Once the analyses are completed, the data are dumped into the SIS data system by the LIS system for merging with the field data (Figure 11). Once the laboratory analysis is completed, the field sheets are keypunched and submitted for inclusion in the SIS data base.

The field data are verified by comparing the output of the field data from SIS to the original field sheets. These sheets are screened by the computer program (which catches invalid station identification, dates, sample number etc) and by manual screening (by comparing the sheets with the computer output). If errors are detected, the data file is edited and rechecked. Once all the mergers have been completed, the data go to the validation step. Up to this point the data handling procedures are basically the same for each type of monitoring programme. The data processing and validation procedures from this point are different for each type of sample. At the time of the audit, detailed procedures had only been developed for the event precipitation data set. Similar, but undetermined procedures will be developed for the other types of data as the data analysis procedures develop.

5.1.4 General Data Validation Procedures

Data validation procedures have been implemented for the event precipitation monitoring results. These procedures are used to automatically screen the data collected according to a set of predetermined criteria. The basic algorithm (Figure 12) that has been used to perform these validation steps will be used for the data from all of the APIOS monitoring networks. Only the details of the specific checks and screening procedures will have to change.

The general procedure may be summarized as follows:

1) The merged data set is subjected to the computer screening programme.

2) All data points exceeding the limits, or failing the screening criteria are listed and examined.

3) Decisions (objective or subjective) are made regarding data quality.

4) Corrections are made if possible.

5) Data are rejected or flagged and returned to data base.

The important areas of these validation procedures are the development of the specific screening criteria to be used and the guidelines presented for making the final decision on whether or not to reject the data. These questions are examined for different areas of the APIOS programme in section 5.3 below.

5.1.5 Data Handling Quality Assurance and Quality Control

The data collection, editing and validation procedures described above illustrated that the existing APIOS data handling system has been set up to permit careful and correct data transmittal and storage. The computerized systems available for the entry and storage of the field and laboratory data provide an excellent system for manipulating the data to automatically perform various screening and display functions. Procedures have been established for ensuring that the field information data are correct before detailed data manipulations are undertaken. These data handling procedures have developed over the first two years of the APIOS programme, and now seem to be running smoothly. However, the system has not been documented. A well documented system should be generated to explain the procedures used and to describe the quality control steps that should be taken at each stage of data handling. Some of the routine procedures that should be considered a part of the operating procedure include:

- Specific procedures for processing and editing data and comparing original records to the final data base.
- Schedules for ensuring data steps are carried out in a reasonable time frame.
- Mechanisms for reporting data handling problems and implementing corrective action.
- Reporting structure and responsibilities within the data handling and analysis group at the head office.

The documentation of these procedures is particularly important for describing the routine, but time consuming tasks carried out by data clerks, since there has traditionally been a rapid turnover in staff at this position and significant training is required.

Scheduling the handling of data is also very important to ensure that the data are processed quickly and properly and to provide a means of evaluating data quality on time scale as close to real time as possible.

The results of ongoing studies (routine or special studies) to investigate sampler precision (routine) or sampler performance (instrument comparisons and evaluations) should also be reported routinely and quickly. It is not sufficient to simply collect the data. It must be evaluated and reported to users on a timely basis in order to evaluate the overall data quality. If, for example, questionable samples are collected by a particular sampler, it should evaluated as quickly as possible to avoid expending considerable effort in collecting and analysing data that may not be representative.

The QA/QC system should also be modified to incorporate more use of routine quality control checks on sampling and analysis such as the submission of blanks, spiked samples and split samples in addition to the present use of co-located samplers. The procedures developed for the submission of these quality control standards should be such that they are processed exactly as routine samples without the knowledge of the technician, lab analyst or data clerks.

5.2 Status of Data Analysis and Reporting

At the beginning of the audit programme the data validation procedures were under development for the event precipitation data. As the audits progressed these validation procedures had been implemented and a portion of the event data set was published. The data validation procedures are currently being developed for the cumulative wet data. Once these are completed the air sampling and dry side sampling for the cumulative data will be addressed.

It is important that these programs be developed as quickly as possible so that a routine, "turn key" type system is available to generate, quality assure and report the network data as quickly as possible. Under the current system, large amounts of very valuable data are being collected, but are not generally available to users for a considerable length of time after collection. Once the procedures have been developed and tested it will be possible to get the data to users much more quickly. Estimated turnaround times for the data collected by the various types of monitoring programmes (once the screening and validation procedures have been implemented) have been prepared by APIOS staff and are presented in Figures 13-16. These figures indicate that once the routine data processing and validation systems are in place, the network should be able to quickly produce data reports, with the rate limiting step being the laboratory analysis.

The status of the data collected by the network (as of September 1982) is summarized in Figure 17. This figure indicates that the only data to be formally released by the network is the event precipitation data from September 1980 to December 1981. At the present time the data validation procedures are being developed for the cumulative precipitation data up to December 1981 and the data should be published shortly. The timing for the publication of the remaining data is uncertain and depends on the timing of development of the data access, merging, calculation and manipulation routines.

The audit programme revealed that the rate determining step of the data reporting procedures was the development and implementation of the computer routines to perform the data validation and screening procedures. It was felt that inadequate staff were available for the data handling procedures and that the data base scientist responsible for the development work was overly involved in the day to day operations of data handling. This resulted in inefficient use of human resources. The data validation procedures could be greatly enhanced by the addition of support staff to perform the routine aspects of data handling and free the data base scientist for development work. If this additional staff becomes available it is recommended that the priorities for data reporting be established and a schedule for implementing them be developed.

5.3 Data Validation Systems

Data validation and screening sysems are used to evaluate the raw data before including them in the final data base. A number of descriptive and statistical routines are run on the data to flag unusual or suspect data so that they may be scrutinized more carefully and decisions can be made on whether or not to include them in the data base.

To date, specific data validation procedures have been developed only for the event precipitation data. In future, similar programs will be used to develop these procedures for other areas of the program. In the following section, the procedures used for validating the event precipitation data are described and evaluated. Suggestions are also presented for the procedures to be used for some of the other areas of the programme.

The specific set of data screening criteria to check sample integrity for the event precipitation data consists of:

1) Collection efficiencies (relative to the standard or nipher gauge) are flagged if they are outside the range 50 - 120 % for sample volumes greater than 50 ml.

2) Ion balances outside the range -30 to +10 % are flagged for further evaluation.

3) Predicted vs Measured Conductance is used to determine if there is a significant parameter missing or suspect values reported.

4) Lab pH vs Field and theoretical pH is checked to look for significant pH discrepancies.

5) The free H^+ vs total H^+ ratio is calculated.

6) The results of the individual chemical species are compared statistically to ensure that data are not reported below the analytical detection limit. High level outliers are flagged based on upper limits derived from historical data and data grouping on a regional basis.

7) The Dixon Ratio Test is used to flag outliers.

In addition, the event samples collected are examined on a regional basis to look at outliers. The Dixon ratio test is used to identify values within a regional group that may be outliers. Once these data points are flagged, they are reviewed (usually by the data base scientist) and objective or subjective decisions are made to either include, flag or reject the data. In most cases the data points are simply flagged with an appropriate letter code and retained in the data base.

In general, the data validation system for the event precipitation data seems to be well conceived and implemented. Now that the system is operational, it is important to use it to validate the data as soon as possible after the data are collected.

Some very useful supplementary analysis programmes have also been developed to look at the statistics associated with comments, events missed and collection efficiencies by sampler regions or season over various time periods (e.g. Figure 18). This type of summary report can be very useful for the QA co-ordinator to use for identifying site, sampler or operator problems on a regular basis. The use of this type of summary should be expanded and used on a regular basis to evaluate the quality of the data collected. Another display that may prove useful would be a display of a calendar of events on a regional basis to show when events occurred and were collected at each of the event sites. This type of display would help to ensure that representative samples were being collected by all sites in a region.

These types of precipitation data summaries should be used in conjuction with the technician sampling summaries described (in Section 5.1) above and manual (or visual) screening of the data to spot obvious errors and gross sampling problems. The results of sampler configuration checks (such as sensitivity, delay time etc.) should also be used to spot general trends in the data that may not be detected by computer analysis programs.

When generating the data validation procedures for other parts of the APIOS programme, it is recommended that general procedures used for the event precipitation data be followed. It is important that these procedures be developed and implemented as quickly as possible in order to perform evaluations of the data quality during, and as soon after collection as possible. Some additional points that may be considered in the continuing development of these procedures include the following:

- investigation of seasonal dependence of screening criteria i.e. should the same chemical parameter limits be applied for summer and winter data

- ratioing specific parameters (e.g. $SO_4^=/NO_3^-$) to illustrate abnormalities that do not show up in simple screening statistics.

- comparability of different samplers employed to make the same measurement (e.g. SES and Aerochem Metrics) - if they are not comparable, differences must be established and data flagged

- as calibration procedures are developed for air sampling equipment, the calibration factors should be monitored. The application of the factors will have to be done in the field (technician) or in the data base manipulations.

- when the air sampling data are manipulated, the procedures for correcting for passive sampling and blanks must be carefully considered. The variability of passives should be determined and accounted for in the calculation.

- the reporting of data at or below the detection limits of the various analytical procedures should be evaluated. In each case, a detection limit value should be adopted for each parameter and data should not be reported below that value. The differences in the various laboratory codes to indicate low level analysis should be resolved and explained in data reports.

-

- the routine use of quality control samples (blanks, spiked samples and duplicates) for field and laboratory sampling should be used to monitor data quality.

- periodic checks of winter time storage gauge calculations by technicians should be carried out. This is a complicated calculation with many potential areas for error.

- when incorrect sample collection periods are indicated, the data should be evaluated in more detail to see if this affects the validity of the sample. This also applies to multiple day event samples.

5.4 Performance Audit of Data Handling and Validation Procedures

The data validation and reporting procedure for event precipitation were evaluated by examining a small set of data very carefully. It was originally suggested that 'dummy' data sets be used to carry out the checks. However, after the preliminary review of the data systems it was apparent that the data validation was not occurring on a regular basis, and that similar information could be obtained by examining historical data in detail.

All data sheets, results of screening and data outputs for the event data collected in the SW region in September and October 1981 were examined in detail to ensure the following:

- information from the field matched that in the data base
- LIS and SIS output matched properly
- all data were reported

In addition, the results for various parameters were manually screened and compared with the results of the data screening. The data were also examined for improper sampling periods, multiple day samples and incorrect labelling or identification of samples. The data collected over the four event sites were also compared with each other to see if the samples collected were consistent between sites. Many of these checks are the types of manual screening checks that have been recommended above and should be carried out by either the field technicians or the quality assurance co-ordinator. The results of these checks and summaries are presented below.

1) In all cases there was a listing in the data base corresponding to all field sheets. No data points were missing. In one case the LIS output was not found, however, the remainder of the data were present. This indicates that there was a complete data set present.

2) The manual screening of the data set revealed a number of questionable data points as presented in Table 27. In most cases the data screening procedures flagged improper data points, but others were suspect based on field comments and observation of levels that were high, but not exceeding the screening criteria. The results of the Dixon Ratio test that were made available after the initial audit indicated that these types suspect data are flagged on a rational basis.

3) The monthly volume-weighted average concentrations at the four event stations have been calculated and are presented in Table 28. The results of these simple types of analyses can be useful in illustrating site specific relationships in the data. In this case the soil based parameters (Ca^{++}, Mg^{++}, K^{+}) are consistently higher at the Longwoods sites indicating a potential soil contamination problem. Speedy awareness of these types of trends can help identify problem areas before a large amount of data is collected.

4) The consistency of precipitation sampling between sites was examined to determine whether or not the sites were reporting the same events. To carry out this investigation, the precipitation data amounts at the sites were plotted for each event. The precipitation amounts recorded at local CLIMAT weather stations were also plotted to give a detailed picture of event coverage. This analysis indicated that the Melbourne site collected significantly different information than the other sites on several occasions. The evidence is presented in Table 29 which indicates that the operator was either picking up the samples on the wrong day, or indicating the wrong dates on the sample sheets. This type of presentation also illustrated the fact that many of the sites do not report trace amounts of precipitation.

This is the type of analysis that is recommended for the technician field summaries. Comparisons between sites could be done quickly and would result in a significant increase in the confidence in the data.

5.5 Data Handling and Validation - Summary and Recommendations

In general the data collection, storage and preliminary editing procedures of the APIOS programme are well conceived and operate smoothly. Sound data screening and validation procedures have been developed and implemented for the event precipitation monitoring programme and are currently under development for the cumulative monitoring activities. The timing of the development for the other programmes is somewhat uncertain.

The routine quality control and quality assurance procedures required for data handling at the collection and data base level of the programme have not been well defined or documented.

Some specific recommendations for the institution of these procedures and further development of the QA/QC system are presented below:

1) The remaining data screening and data validation procedures should be developed and implemented as quickly as possible. The remaining tasks should be identified and a schedule prepared for the completion of them. Additional staffing is required to assist the data base scientist and allow him to put more effort into the development of these procedures.

2) Once all of the data handling and analysis procedures are developed they should be properly documented. This documentation should include specific data handling procedures as well as the QA/QC steps that will be associated with them. Some of the QA/QC steps that should be considered include:

   - routine use of blank, duplicate and spiked sample submissions to evaluate network accuracy. Careful consideration will have to be given to the preparation and distribution of these control standards.

   - routine evaluations of network precision based on duplicate sampling. The use of duplicate sampling should be expanded to include the air sampling as well as precipitation monitoring systems.

   - Manual data and sample screening should be implemented at two levels. The technicians should be responsible for comparing raw data collected by stations, validating field sampling information and providing regular summaries of sampling activities including calibration and maintenance, unusual events, sampling problems and corrective action to be taken.

The network QA co-ordinator should be responsible for reviewing the technician summaries and then reviewing the data reported in terms of the sampling information. He should also be responsible for reviewing the data on a regular basis to look for errors or inconsistencies in the data not detected by the computer validation routines. He should also be responsible for scheduling the corrective action schemes required to correct data related problems.

3) Data collected during special studies should be subjected to the same strict QA/QC procedures as the network data. These data are very important for special evaluations and network intercomparisons and must therefore be of high quality. Before each special study begins a quality assurance plan should be generated to describe QA/QC procedures to be followed throughout the special study.

4) Data quality should be regularly reported in the QA reports. The data portion of the report should include at least the following points:

- statistics on data recovery and reasons for lost data
- reporting of results of QA/QC checks including:
    - blind sampling
    - blanks
    - duplicates
    - spiked samples
- estimates of network precision and accuracy (where possible)
- summary of data status and projected schedule
- summary of data quality related problems and anticipated action

6.0 LABORATORY SAMPLE ANALYSIS

During the preliminary review of the overall network operating systems and quality assurance/quality control procedures it was felt that the majority of the effort of the audit programme should be spent on field monitoring operations and data handling procedures rather than reviewing laboratory procedures since the laboratory QA/QC system appeared to be well conceived and implemented. The audit of the laboratory systems was therefore undertaken as an overall review and evaluation of operating and QA/QC procedures, rather than a detailed critical review of the individual components and specific analyses.

The laboratory audit consisted of a systems and performance audit. The systems audit consisted of reviewing of existing documentation and interviewing laboratory personnel to document the operating and QA/QC systems. The performance audit consisted of observation of sampling handling, sample analysis and data entry procedures at various stations within the laboratory during several visits to ensure that proper procedures were followed. The submission of prepared samples and duplicate samples from the field without the knowledge of the laboratory staff were also used to evaluate laboratory precision and reproduceability.

A total of four visits were made to the laboratory. The first visit had the two-fold purpose of obtaining general information on the QA/QC system and allowing the auditors to become familiar with the facility. Visit number two comprised of being led step by step through the QA/QC procedure as it related to sample handling, storage and analysis. Visits 3 and 4 involved viewing ongoing sample handling and analytical procedures, discussing the various procedures with individual staff members and observing staff adherence to the established procedures.

6.1 Systems Audit

The systems audit consisted of a review and evaluation of the sample handling, analysis and data entry procedures for the laboratory system. The handling and analysis procedure, for the various types of samples are presented in Figures 19 to 21 and are summarized briefly below.

The general procedure for all samples is that they are received at the sample submission area and stored (under refrigeration if required) until they are logged into the Laboratory Information System (LIS). The LIS system is a computerized data entry and sample tracking system used throughout the Ministry of Environment laboratories. It provides a means of routing the samples to the appropriate work stations. It automatically monitors the length of time the samples wait before analysis and ensures that all requested analyses are carried out. An automatic queuing system is used to ensure that the analyses are carried out in order of priority and that samples that have been waiting the longest are analyzed first. Once all analyses are completed, various checks are performed to screen the data and to ensure all data are present. The results are then reviewed by the laboratory supervisor before being released. The data are then released to the Ministry of Environment's Sample Information System (SIS) for merging with field sampling information and subsequent data validation and reporting.

The procedures for accessing and operating the LIS and SIS systems are well documented (8, 9) and seem to be understood by all of the operators. This system provides an excellent framework for sample tracking and data processing.

The sample analyses carried out at the individual work stations are also documented (10,11) in detail. These documents provide detailed description of the procedures to be used, sample preservation steps to be followed, characteristics of the analysis (accuracy, volumes required, detection limits) equipment required and precise sample handling and analysis procedures. The data calculations are also described and references to appropriate QA/QC documents are provided as required.

Quality control and assurance form an integral part of the laboratory systems' routine operating procedures. The overall philosophy of laboratory QA/QC is well documented (12) and the objectives of the various QA/QC steps are described. The quality control steps for various analyses are also well documented (13, 14) and have been implemented into the standard operating procedures.

A list of all of the documentation reviewed as part of this systems audit is presented below:

1) "Quality Control Philosophy".
2) "The Definition of the Detection Criterion, Detection Limit and the Reporting of Analytical Results".
3) "Outlines of Analytical Methods".
4) "Quality Control Procedures and Objectives 1976".
5) "Quality Control and Data Evaluation Procedures - Section I Analytical Reproducibility".
6) "Quality Control Data for Heavy Metals Analysis".
7) "Acid Precipitation Sample, Preparation Procedures A & B".
8) Results of round-robin conducted by U.S. Geological Survey.
9) Various additional analytical methods specific to certain analyses.

The analysis system resulting from these documented procedures is a well conceived and properly implemented set of procedures that results in the efficient processing of samples with appropriate quality control and assurance procedures associated with them.

Some of the important QA/QC procedures applied to the APIOS data are summarized below:

- Systematic error in analysis is identified by the use of Youden's technique (15) in which intra-laboratory variability is evaluated by the repeated use of QC samples within different analytical runs. Control charts are used to monitor the repeated analysis of the QC samples and to spot when warning (±2 σ) limits or out of control (±3 σ) conditions exist. This is a real time system that spots out of control conditions as they occur. The frequency of these tests depends on the analytical procedure being applied.

- corrective action procedures are documented and followed to rectify out of control systems.

- the control standards are prepared and monitored under very strict criteria. New control standards are prepared and analysed before the old ones are exhausted to ensure continuity in QC checks.

- actual samples are re-analysed within runs and between runs to evaluate reproduceability. The frequency of re-analysis depends on the analytical procedure.

- specific definitions are followed for reporting parameters such as:
  - detection limit and criteria
  - within and between run precision

  - resolution and sensitivity

- the priority of sample analysis for limited volumes has been established as:
  1) pH/acidity
  2) Anions
  3) NH_4
  4) Cations
  5) Conductivity

  for event precipitation samples. For cumulative samples, the same priority is assigned. If there is sufficient volume, the sample is then submitted for metals analysis.

- reports on data quality including
  - precision
  - accuracy
  - detection limits

  are routinely produced

- data entry is verified manually by lab technicians and reviewed by supervisors prior to release.

6.2 Performance Audit

The performance audit of laboratory procedures was carried out to observe sample analysis operations to determine whether or not the formalized procedures identified in the systems documentation were being followed. It also included the submission of several sets of prepared samples to examine the reproduceability of sample analysis.

The visits to the laboratory indicated that staff generally followed the documented procedures for analysis and QA/QC monitoring. In particular, strict adherence to the procedures for the use of QC samples, control charts and sample re-analysis was observed.

The various technicians carrying out the analyses generally exhibited good sample handling techniques and performed the analyses in a careful and efficient manner. In general the samples were maintained under proper conditions (refrigerated, not exposed to atmosphere etc.) throughout the sample handling procedures.

The permanent and contract staff seemed to be well trained and had the experience to meet the needs of their positions. The training of the short-term (student) analysts, however, did not seem to provide extensive enough training to leave the new analyst unsupervised as quickly as possible. A formalized training program and "break-in" period should be considered in addition to the current "on the job" training to ensure that data quality is maintained while a new analyst learns the job.

The data entry to the LIS system appears to run smoothly and the double entry from lab bench sheets and checking by supervisors leads to correct data appearing in the final data set. This was quantitatively confirmed by manually comparing lab bench sheets to the final data base for many samples with no errors being observed.

One area of concern that was noted during the laboratory audit was the turnaround time for some of the samples. The event precipitation samples are processed in at a timely fashion (1-3 wks depending on laboratory sample load) however, some other samples are not.

The time required to analyze the cumulative samples is often the order of several months - mainly as a result of the time required for metals analyses. This is not of immediate concern as the samples are stabilized and properly stored, however it does delay the release and subsequent reporting of the data.

The time required to complete the extraction and analysis of the air sampling filters however, may be a significant factor in determining data quality. It often takes several months for these extractions and analyses to occur and to date, no tests of filter stability have been documented. These tests should be designed and carried out in order to determine the validity of the large number of samples that have been collected but not analyzed. The reason for the delay in the analysis of these filters seems to be manpower-related since the filter extractions are a time consuming and labour intensive process.

Another area of concern was the shortage of space within the water quality laboratory. In several cases the technicians seemed crowded, and the sample preparation and analysis areas cramped. This shortage of space also led to the storage of chemicals near a sample preparation area, which is not recommended as good laboratory practice.

Some additional areas of concern arise as a result of some of the field sampling procedures. The leaking cumulative sample bags pose a significant sample handling problem to the lab. The "original" and "transfer" bag for taking samples may be confused, and the acid leach for metals analysis may be undertaken on the wrong bag. In many cases it is not possible to repair the bags and the leaching does not take place.

Several air sampling filters were also observed to be improperly submitted. In some cases the filters were not folded, resulting in possible sample loss on the bag walls. Improperly loaded filters (cut edges, etc.) were also observed. It may prove useful to adopt laboratory comments for these types of problems.

The scheduling and organization of sample delivery to the laboratory often presents sample analysis problems. The communication between the lab and network regarding sample arrival should be improved.

6.3 Laboratory Analysis of Prepared and Blank Samples

Several types of prepared blind samples were submitted to the laboratory to examine parameters such as:

- laboratory reproduceability from field samples
- potential contamination from operator handling
- deliberate contamination of precipitation samples and filters to examine what parameters might be affected when improper procedures were followed.

The samples used consisted of a composite precipitation sample, deionized water samples and various types of filters. These samples were exposed to different sampling conditions as described below.

1. Laboratory Reproduceability

A total of 10 sets of duplicate (split) samples were submitted from event sites in the Southwest region. These samples consisted of large volume events collected in the Aerochem Metrics samplers during May and June 1982 that were split into 2 separate event bottles and submitted as regular event samples under separate submission numbers. The results of the analysis of these samples for 10 events are presented in Table 30.

These results indicate that the results between the pairs of samples generally agree extremely well. In one instance (Event #9) there is a significant difference in the results reported. In both cases, however, the pH values were extremely high (6.77 and 7.33) due to high NH_4^+ levels. This was probably a contaminated sample and the split samples may not have been homogeneous (i.e. more contamination substance in one of the samples). The remainder of the results indicate excellent agreement.

An additional check of laboratory reproduceability was carried out by submitting four identical samples of composite precipitation sample for blind analysis by laboratory staff. These results also showed excellent agreement as illustrated in Table 31.

2. Operator Handling Checks

Prepared samples (deionized water or composite precipitation samples) were given to a number of operators to handle as they would normal samples. These tests were carried out to determine whether or not measurable contamination of the samples was occurring as a result of operator sample handling.

The first of these tests was undertaken by introducing a composite sample to the SES collector bag of the Wellesley sampler. The operator was then asked to handle the sample as he would a normal event sample. The results of the analysis (Table 32) of this sample with respect to the corresponding unhandled composite, indicate that the handled sample values are higher than the composite for many parameters and the pH is significantly higher. This is probably a result of the fact that the SES bucket was exposed prior to the sample being introduced. This test was probably not an accurate check of operator handling procedures but it does point out the potential for handling errors.

The second set of checks was carried out at two event sites in the Central Region (Table 32) at Raven and Balsam Lakes using deionized water. Duplicate handling samples were obtained by introducing deionized water to clean Aerochem Metrics Samplers for handling by the operator. The results of these tests indicate that the pH's reported after sampler handling, were slightly higher but there were no significant changes in any of the other chemical parameters. The deionized water used in this test was old and obviously not of high quality, but served its purpose for this test. These results (Table 32) indicate that the operator sample handling procedures probably did not affect sample integrity in these cases. Both operators were observed to use correct handling procedures during the sample changes.

A third operator handling check was carried out at the Charleston Lake event site in the Southeastern Region. Samples of deionized water were obtained from the MOE regional lab at Kingston and used for a similar sample handling check. These results (Table 32) indicate that there was no significant contaminaation due to sample handling observed.

These quantitative spot checks of operator handling procedures are the type recommended for routine use at all monitoring sites within the APIOS programme. The results of these types of tests can be used to ensure that operator procedures do not lead to or cause sample contamination.

3. Deliberate Contamination of Samples

A set of simple tests were undertaken to qualitatively examine the effects of improper sample handling on analysis results. A number of samples of various types were deliberately mishandled to see if the effects were noticeable upon sample analysis. In all tests, clean Aerochem Metrics Sampling Bags were used to simulate sample handling procedures and all sample handling and transfer steps were done according to the APIOS field sampling methods. Appropriate aliquots of composite precipitation or D.I. water were used as control samples for each of these tests.

The results of the individual tests are presented in Table 33 and are summarized below:

A. Composite sample in bag and put fingers in it:

- Cl^- increased slightly 0.34 to 0.41 mg/l
- Na^+ increased 0.188 to 0.245 mg/l
- K^+ increased 0.072 to 0.105 mg/l

B. Composite left in jar at room temperature for 3 days.

- total ammonium increased slightly 0.480 to 0.540 mg/l as N

C. Deionized water in bag, ran hand over bag then poured sample into event bottle

- Total ammonium in one sample decreased from 0.056 mg/l as N to 0.012 mg/l as N; the same sample had an increase in Na from 0.005 to 0.190 mg/l of Na.

D. Leach caps of events bottles with deionized water

A) Black Metal Cap With Yellow Lining

- slight increase in pH 6.1 to 6.8
- slight increase in sulfate 0.05 (<w) to 0.10

B) White Metal Cap With Lining

- slight increase in pH 6.1 to 6.5

C) White Plastic Cap

- slight increase in pH 6.1 to 6.3

E. Deionized water in bag, person stood over bag and shook hair and dirt from clothes into sample.

- decrease in pH 6.1 to 5.6
- increase in Ca^{++} 0.005 to 0.015

F. Left deionized water sitting on a dirty spot in bag.

- decrease in pH 6.1 to 5.6

Deliberate contamination was also attempted on different types of air sampling filters to evaluate the effects of improper handling. The results of these tests (presented in Table 34) indicate that some effects of improper handling or exposure to room air are observed, but they are difficult to interpret due to the variability and the small number of samples used.

6.4 Summary and Recommendations

In general, the operating procedures at the APIOS laboratory facilities were found to be well designed and resulted in accurate, efficient handling of samples. A rigorous QA/QC system has been designed and developed to ensure monitor and report on the quality of the data produced by the laboratory. The only major quality related problem observed was in the sample analysis turnaround time required for the air sampling filters.

The recommendations generated as a result of the laboratory audits are presented below:

1) The QA/QC programmes of the laboratory and monitoring programmes should be tied more closely together to help ensure the overall network quality assurance. The laboratory and network QA co-ordinators should work together to design the overall approach to QA/QC for the network. Some factors that should be given immediate consideration include:

   - routine introduction of duplicate, split, blank and prepared samples from the field to the laboratory. Careful consideration will have to be given to the preparation and analysis of these control samples as well as the interpretation of the data they produce

   - determination of acceptable sample analysis times and the design of tests to check the effects of long-term sample storage

- generation of routine QA data reports, including the following information about laboratory procedures
  - QA/QC results as they apply to APIOS
  - accuracy, precision, and completeness of data reported
  - results of laboratory round robins

2) A summary of laboratory operating and QA/QC procedures as they relate to the APIOS programme should be prepared for insertion into network and QA documentation.

3) Sample analysis turnaround times should be imposed where possible - particularly for the air sampling filters.

4) Formalized training procedures should be considered for short-term staff in order to maintain data quality.

5) The space requirements of the water quality laboratory should be evaluated and expanded if required.

7.0 SUMMARY AND RECOMMENDATIONS

In general, it was found that the APIOS programme had implemented sound operating procedures for all stages of the monitoring activities. The network design, sample handling methods, data reduction and validation procedures and laboratory analyses procedures were all found to be well designed systems that were generally followed by the staff members.

The preliminary stages of a quality assurance programme have been established. A preliminary quality assurance plan has been written to address many of the refined QA elements and the quality assurance co-ordinator's position has been filled. However, the implementation of many of the aspects of a detailed quality assurance programme and routine quality control checks have not been incorporated to date.

A list of recommendations generated as a result of the audit and evaluation programme are presented below:

1) The quality assurance plan should be rewritten and restructured so that all important elements of a sound QA programme are identified. This plan should identify specific quality control checks that should be applied to each stage of the programme, how they should be monitored and what corrective action should be taken if out of control conditions are experienced.

2) The laboratory and network quality assurance procedures for the APIOS programme should be linked more closely together. The QA co-ordinators for network operations and the laboratory should work together to provide the overall APIOS quality assurance programme. The extensive QA/QC experience in the laboratory may prove helpful in developing the network QA procedures.

3) The representativeness of the monitoring sites should be monitored on a regular basis. The site specific documentation should be kept up to date, and the network or QA co-ordinator should be aware of any on site changes (physical, operator or instrumentation) that may affect the sample quality. Audits of site representativeness should be carried out for the remaining sites until all sites have been evaluated.

4) Data screening and validation programmes should be developed and documented for all types of network data as quickly as possible.

5) A network documentation package should be assembled that incorporates all network operational procedures. This documentation should be distributed to all appropriate members of the programme to ensure that current procedures are available and followed at all stages of the programme. A

document control system should also be incorporated to ensure that revisions to the procedures can easily be distributed to all members of the programme.

6) Routine quality control procedures should be incorporated for the field and data monitoring programmes. The following areas should be considered.

- routine submission of blank, split and prepared precipitation samples.
- routine instrument calibration and maintenance
- raw data summaries by technicians before data submission
- manual data screening by QA co-ordinator
- frequent checks of operator sampling procedures

7) Evaluation of the instruments sampling and measurement methods employed in the network should continue. In particular the following should be considered:

- improvements to Sangamo collector including: fit of sample bags in the collector, leaking bags, winter time knife edge and sensor characteristics
- the sensor characteristics of the Aerochem Metrics sampler should be evaluated in detail
- passive correction procedures for air sampling data

- precipitation gauge measurements (intercomparison and calibrations)
- field pH (timing requirements)
- precision studies for air sampling
- standardization of filter handling procedures

8) Quality assurance reports should be prepared on a regular basis to discuss the performance of the networks and the status of current quality assurance related activities. Some of the important elements that should be reported include:

- a statement of data status
- a summary of data recovery and reasons for lost data
- summary of QA activities and results
    - new activities
    - accuracy and precision
    - laboratory round robin results
    - problems and anticipated action
- revisions to QA/QC procedures

9) The time required for the laboratory analysis of air sampling filter should be improved. Studies should also be undertaken to determine the validity of the samples that have already been collected, but remain unanalyzed.

10) Quality assurance plans and procedures should be considered for all future special studies.

Table 1 - Summary of Site Documentation - Event Sites Northwestern Region

Site Name	I.D. #	UTM Coordinates	Site Drawing	Site Photographs	Site Description	Electrical Configuration	List of Equipment	Site Evaluation	Topo. Map	Comments
Ely/Fernberg	6051	No	No	Yes	No	No	No	Yes	No	No data sheets on file.
Lac la Croix	6061	Yes	Yes	Yes	Yes	No	No	Yes	Yes	
Quetico Center	6071	Yes**	Yes*	Yes	Yes	No	No	Yes	No	* Quetico Center Map provided as well. ** On-site drawings.
Forbes Twp.	6081	No	Yes	Yes	No	No	No	Yes	No	Proposed site Data sheets on file

Table 2 - Summary of Site Documentation - Event Sites - Southwestern Region

Site Name	I.D. #	UTM Coordinates	Site Drawing	Site Photographs	Site Description	Electrical Configuration	List of Equipment	Site Evaluation	Topo. Map	Comments
Longwoods	1011 EP, SS 1012 EP	Yes	Yes*	No	Yes	Yes	No	Yes	Yes	* Missing height of sampler.
Melbourne	1021 EP	Yes	Yes*	No	Yes	Yes	No	No	Yes	* Missing height of sampler.
North Easthope	1031 EP	Yes	Yes*	No	Yes	Not ** Complete	NO	NO	Yes	* Missing height of sampler. ** Shows power location but no specifications with regard to location of cable, breakers, type of receptacle.
Wellesley	2011 EP	Yes	No	No	Yes	**	No	No	No	** No specifications as mentioned above.

Table 3 Summary of Site Documentation - Event Sites - Central Region

Site Name	I.D. #	UTM Coordinates	Site Drawing	Site Photographs	Site Description	Electrical Configuration	List of Equipment	Site Evaluation	Topo. Map	Comments
Dorset (Lab)	3011 LP, SS 3012 LP	Yes	No	No	Yes	No	No	Yes	No	Incomplete documentation
Nithgrove	3021 LP	Yes	Yes*	No	Yes	No	No	No	No	* Based on "probable site". Drawing should be refined.
Balsam Lake	3031 LP	Yes	Yes**	*	Yes	No	No	Yes	No	** Drawing should be refined. * Brochure submitted of park with pictures (none of site).
Raven Lake	3041 LP	Yes	Yes	No	No*	No	No	Yes	No	* No description on how to find location.

Table 4 Summary of Site Documentation - Event Sites - Southeastern Region

Site Name	I.D. #	UTM Coordinates	Site Drawing	Site Photographs	Site Description	Electrical Configuration	List of Equipment	Site Evaluation	Topo. Map	Comments
Charleston Lake	4011 EP, SS 4012 EP	Yes	Yes*	No	Yes	No	No	Yes	Yes	* Poor drawing.
Railton	4021 EP 4022 EP	Yes	Yes	No	Yes	No	No	Yes	Yes	
Graham Lake	4031 EP	Yes	Yes*	No	Yes	No	No	Yes	Yes	* Missing N. direction and ground cover not indicated. Height of trees.
Whitman Creek	4041 EP	Yes	Yes*	No	No	No	No	Yes	Yes	* "probable site"

Table 5 Summary of Site Documentation - Cumulative Sites - Southeastern Region

Site Name	I.D. #	UTM Coordinates	Site Drawing	Site Photographs	Site Description	Electrical Configuration	List of Equipment	Site Evaluation	Topo. Map	Comments
Kaladar	4051 S	Yes	Yes	No	Yes	Yes	No	Yes	Yes	
Smiths Falls	4061 S	Yes	Yes*	Yes	Yes	Yes	No	Yes	Yes	* North not indicated.
Dalhousie Mills	4071 S	Yes	Yes*	Yes	Yes	Yes	No	Yes	Yes	* North not indicated.
Golden Lake	4081 S	Yes	Yes*	Yes	Yes	Yes	No	Yes	Yes	* North not indicated.

Table 6 Summary of Site Documentation - Cumulative Sites - Central Region

Site Name	I.D. #	UTM Coordinates	Site Drawing	Site Photographs	Site Description	Electrical Configuration	List of Equipment	Site Evaluation	Topo. Map	Comments
Dorset		No	No	Yes	No	No	No	Yes	Yes	Incomplete documentation.
Milton	3051 S	Yes	Yes	Yes*	Yes	Yes	No	Yes	Yes	* Before sampler installed. North not indicated.
Uxbridge	3061 S	Yes	Yes	No	Yes	Yes	No	Yes	Yes	
Wilberforce	3071 S	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	
Campbellford	3081 S	Yes	Yes	No	Yes	Yes	No	Yes	Yes	
Toronto										No information on file.
Coldwater										No information on file.
Whitney	5091 S	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	

Table 7 Summary of Site Documentation - Cumulative Sites - North Western Region

Site Name	I.D. #	UTM Coordinates	Site Drawing	Site Photographs	Site Description	Electrical Configuration	List of Equipment	Site Evaluation	Topo. Map	Comments
Dorion	6011 S	Yes	Yes	Yes	Yes	No	No	Yes	No	
Nakina	6021 S	Yes	Yes	Yes*	Yes	Yes	No	Yes	No	* Before samplers installed - indicates lots of residential activity nearby - possible overhead wires.
Ear Falls	6031 S	Yes	Yes	Yes	Yes	No	No	Yes	No	
Pickle Lake	6041 S	Yes	Yes	Yes*	Yes	No	Yes	No	No	* Looks like excellent site.
ELA	6091									No information on file.
Winisk	6101									No information on file.

Table 8 Summary of Site Documentation - Cumulative Sites - North Eastern Region

Site Name	I.D. #	UTM Coordinates	Site Drawing	Site Photographs	Site Description	Electrical Configuration	List of Equipment	Site Evaluation	Topo. Map	Comments
McKellar	5011 S	Yes	Yes	No	Yes	Yes	No	Yes	Yes	
Killarney	5021 S	Yes	Yes	No	Yes	No	No	Yes	No	
Bear Island	5041 S	Yes	Yes	No	Yes	No	No	Yes	No	
Ramsey	5051 S	Yes	Yes*	No	No	No	No	Yes	No	* Poor drawing.
Mattawa	5031 S	Yes	Yes*	No	Yes	No	No	Yes	Yes	* Poor drawing. - ground cover not indicated.
Gowganda	5061 S	Yes	Yes*	No	Yes	No	No	Yes	No	* Poor drawing. - ground cover not indicated.
Moonbeam	5071 S	Yes	Yes*	Yes**	Yes	No	No	Yes	Yes	* Poor drawing. ** Photos taken before samplers installed.

...cont.

Table 8 Summary of Documentation - Cumulative Sites - North Eastern Region (cont.)

Site Name	I.D. #	UTM Coordinates	Site Drawing	Site Photographs	Site Description	Electrical Configuration	List of Equipment	Site Evaluation	Topo. Map	Comments
Attawapiskat	5081 S	Yes	Yes*	No	Yes	No	No	Yes	No	* Possible interference from Hydro lines.
Whitney	5091 S	Yes	Yes	No	Yes	Yes	Yes	Yes	Yes	
Burwash										Station identification sheet only.
Lively										Station identification sheet only.
Hanmer										Station identification sheet only.

Table 9 Summary of Site Documentation - Cumulative Sites - South Western Region

Site Name	I.D. #	UTM Coordinates	Site Drawing	Site Photographs	Site Description	Electrical Configuration	List of Equipment	Site Evaluation	Topo. Map	Comments
Colchester	1041	Yes	Yes*	No	Yes	Yes	No	Yes	Yes	* Missing N on map.
Merlin	1051	Yes	Yes	Yes*	Yes	Yes	No	Yes	Yes	* Photocopy of aerial and site photos.
Pt. Stanley	1061 S	Yes	Yes*	No	Yes	Yes	No	Yes	Yes	* Land relief not indicated.
Wilkesport	1071 S	Yes	Yes**	No	Yes	Yes	No*	Yes	Yes	* Sangamo only! ** North not indicated.
Alvinston	1081 S	Yes	Yes	No	Yes	Yes	No	Yes	Yes	
Shallow Lake	1091 S	Yes	Yes	No	Yes	Yes	No	Yes	No	
Palmerston	1101 S	Yes	Yes*	No	Yes	Yes	No	Yes	Yes	* North not indicated.

...cont.

Table 9 Summary of Site Documentation - Cumulative Sites - South Western Region (cont.)

Site Name	I.D. #	UTM Coordinates	Site Drawing	Site Photographs	Site Description	Electrical Configuration	List of Equipment	Site Evaluation	Topo. Map	Comments
Dog's Nest East										No information found in file.
South Canfield										No information found in file.
Villa Nova										No information found in file.
North Dufferin										No information found in file.
Bin Brook										No information found in file.
Gorman Park										No information found in file.
Mt. Forest	1181	Yes*	Yes	No	No	No	Yes	No	Yes	* On topographical map.
Huron Park		No	No	No	No	No	No	Yes	No	

...cont.

Table 9 Summary of Site Documentation - Cumulative - South Western Region (cont.)

Site Name	I.D. #	UTM Coordinates	Site Drawing	Site Photographs	Site Description	Electrical Configuration	List of Equipment	Site Evaluation	Topo. Map	Comments
Waterloo	2021 S	Yes	Yes	No	Yes	Yes	No	Yes	Yes	

Table 10a APIOS Technician Site Evaluations**
Northwestern Region - March 1982

Site Name	Site Evaluation	Operator Evaluation	Overall Rating
Fernberg/Ely	9/10	8/10	8.5/10
E.L.A.	8/10	8/10	8/10
* Dorion	6/10	9/10	7.5/10
Pickle Lake	7/10	8/10	7.5/10
Quetico Centre	7/10	7/10	7/10
* Nakina	5/10	8/10	6.5/10
Ear Falls	5/10	6/10	5.5/10
* Lac La Croix	4/10	4/10	4/10
Forbes Township	8/10	9/10	8.5/10

* Sites visited during audit.

** Site rank from 1 - 10 with 10 representing a perfect site.

Table 10b APIOS Technician Site Evaluations**
Northeastern Region - March 1982
" " - Febuary 1981

Site Name	Site Evaluation	Operator Evaluation	Overall Rating	
			Mar/82	Feb/81
Moonbeam			1	3
Burwash			2	2
McKellar			3	6
Ramsey			4	4
* Mattawa			5	5
Gowganda			6	7
* Killarney			7	8
Lively			8	1
Attawapiskat			9	10
Bear Island			10	9
Hanmer			11	11

* Sites visited during audit.

** Sites ranked from 1 (best) to 11 (worst)
- includes instrument related evaluations in 1981 but not in 1982.

Table 10c APIOS Technician Site Evaluations**
Southeastern Region - March 1982

Site Name	Site Evaluation	Operator Evaluation	Overall*** Rating
Cumulative			
* Smiths Falls	5	1	4
Golden Lake	1	2	1
Campbellford	3	3	2
* Kaladar	2	4	3
* Dalhousie Mills	4	5	5
Event			
* Railton	1	1	1
* Whitman Creek	2	4	4
Graham Lake	4	2	2
* Charleston Lake	3	3	3

* Visited during audit.
** Sites ranked from 1 (best) to 5 (worst).
*** Includes instrument characteristics.

Table 10d APIOS Technician Site Evaluations**
Central Region - July 1981

Site Name	Site Evaluation	Operator Evaluation	Overall*** Rating
Cumulative			
* Dorset	1	1	
* Wilberforce	2	3	
Whitney	3	2	
* Milton	N/A		
* Uxbridge	N/A		
Event			
* Raven Lake	2	2	
Nithgrove	3	3	
* Balsam Lake	4	4	
* Dorset	1	1	

* Sites visited during audits.
** Sites ranked from 1 (best) to 4 (worst).
*** No overall rank available.
N/A No evalution on file.

Table 10e APIOS Technician Site Evaluations**
Southwestern Region

Site Name	Site Evaluation	Operator Evaluation	Overall Rating
Cumulative			
Colchester			
Merlin			
* Port Stanley			
* Wilkesport			
Alvinston			
* Palmerston			
* Waterloo			
* Huron Park			
Mt. Forest			
Event			
* Longwoods			
Melbourne			
* North Easthope			
* Wellesley			

* Sites visited during audits.
** No evaluations on file.

Table 11 Summary of Site Visits During Audit Programme

Region	Site	Operator Audits	Site Evaluation	Instrument Audits
North Western	Ely-Fernberg	✓	✓	✓
- Event	Lac La Croix	✓	✓	✓
- Cumulative	Dorion	✓	✓	✓
	Nakina	✓	✓	✓
	Ely	✓	✓	✓
	Lac La Croix	✓	✓	✓
South Western	Longwoods	✓	✓	✓
- Event	North Easthope	No	✓	✓
	Wellesley	✓	✓	✓
- Cumulative	Port Stanley	✓	✓	✓
	Wilkesport	✓	✓	✓
	Palmerston	✓	✓	✓
	Mt. Forest	No	✓	✓
	Huron Park	✓	✓	✓
	Waterloo	✓	✓	✓
North Eastern	Mattawa	✓	✓	✓
- Cumulative	Killarney	✓	✓	✓
Central - Event	Dorset	✓	✓	✓
	Balsam Lake	✓	✓	✓
	Raven Lake	✓	✓	✓
- Cumulative	Dorset	✓	✓	✓
	Milton	✓	✓	✓
	Uxbridge	✓	✓	✓
	Wilberforce	No	✓	✓

Table 12 Summary of Audit Site Evaluations - SE Region

Good to Excellent	Fair to Good	Poor
Cumulative 1) Kaladar - good ground cover - no obstructions or contamination - fair wind break	2) Dalhousie Mills - open site - no wind break - on edge of river valley - garden adjacent to site - operator often changes sample at wrong time	3) Smiths Falls - formerly good site - overhead power lines now pass directly over the sampler - hydro pole near collector
Event 1) Charleston Lake - excellent ground cover and windbreak at site - air sampler located close to deciduous trees 2) Whitman Creek - open area - animals near samplers		3) Railton - formerly fair to good site - garage has been built adjacent to sampler

Table 13 Summary of Audit Site Evaluations - Central and NE Region

Good to Excellent	Fair to Good	Poor
Cumulative 1) Dorset - APIOS special study site and senior technician - site to be moved summer '82 - new site also excellent 2) Wilberforce - good ground cover - fair wind break - sampler located on slight hillside - near Hwy 648 - operator absent - sampler operated by APIOS technician 3) Killarney - good ground cover - operator access problems during winter - operator needs training in sample handling	4) Uxbridge - good ground cover - large T.V. tower within 2.5 H - swimming pool nearby - busy township road 5) Milton - good ground cover - no wind break - busy highway (401) within 500 m - frequent power problems - no access to power - poor instrument configuration and maintenance	6) Mattawa - no ground cover - loose sandy soil is exposed - incinerates garbage near air sampler - nearby road is sprayed with CaCl to keep dust down
Event 1) Dorset - APIOS special study 2) Balsam Lake - brush should be trimmed - different site used for winter and summer - good wind break 3) Raven Lake - good site - operator needs more training		

Table 14 Summary of Audit Site Evaluations - NW Region

Good to Excellent	Fair to Good	Poor
Cumulative 1) Ely, Minn. - NADP special study site - good ground cover and wind break 2) Dorion - fair ground cover - weeds must be trimmed - gravel parking lot nearby	* Quetico Centre - good ground cover and wind break - large gravel and soil piles recently placed near samplers	3) Lac La Croix - heavy boat and airplane traffic during summer - poor security - operator changes sample at wrong times, poor handling procedures 4) Nakina - non representative site in heavily populated area - house construction nearby - overhead wires - heavy diesel emissions in area from train marshalling yard - particularly bad during winter
Event 1) Ely, Minn. - see above * Forbes Township - good ground cover, windbreak - no obvious contamination or obstructions		2) Lac La Croix - see above

* These quick "site only" evaluations were done by aircraft while travelling to other sites.

Table 15a Summary of Audit Site Evaluations - SW Region - Cumulative

Good to Excellent	Fair to Good	Poor
1) Waterloo - good ground cover - no obstructions or obvious contamination - sampler in slight valley - marsh nearby 2) Port Stanley - good ground cover, wind break - no obvious contamination - snow removed by snow blowing - potential contamination - on edge of Lake Ontario 3) Wilkesport - good ground cover, but wide open area	4) Huron Park - on edge of industrial park - agricultural spraying nearby 5) Palmerston - good ground cover - no wind break - open field - sewage lagoon nearby - inconsistent operators	

Table 15b Summary of Audit Site Evaluations - SW Region - Event

Good to Excellent	Fair to Good	Poor
1) Longwoods - good ground cover - gaps in wind break may cause wind channeling - woodstove to heat nearby buildings - site to be moved (spring '82) further from buildings - better location 2) North Easthope - located in nice clearing - garden near sampler - snowmobile traffic - consider moving back in clearing	3) Wellesley - on sloping flood plain with active agricultural activity nearby - open sewage treatment vessel nearby - boiler chimney (intermittent) nearby	

Table 16 Frequency Of Technician Site Visits

SITE	REGION	FREQUENCY OF VISITS
Dorset	Central	Daily
Nithgrove		Weekly
Balsam Lake		Weekly
Raven Lake		Bi-weekly
Milton		Once per month
Uxbridge		Once per month
Wilberforce		Once per month
Charleston Lake	Southeastern	Once or twice per week
Railton		Only if instrument problems occur
Graham Lake		Once or twice per week
Whitman Creek		Once or twice per week
Kaladar		Once or twice per month
Smiths Falls		Once or twice per month
Dalhousie Mills		Once or twice per month
Golden Lake		Once or twice per month
Longwoods	Southwestern	Once or twice per week
Melbourne		Once or twice per week
N Easthope		Once per month
Colchester		Once per month
Merlin		Once per month
Port Stanley		Once per month
Wilkesport		Once per month
Alvinston		Once per month
Shallow Lake		Once per month
Palmerston		Once per month
Mount Forest		Once per month
Huron Park		Once per month
Wellesley		Once or twice per week
Waterloo		Once per month

Table 16 Frequency Of Technician Site Visits (cont'd)

SITE	REGION	FREQUENCY OF VISITS
McKellar	Northeastern	Once per month
Killarney		Once per month
Mattawa		Once per month
Bear Island		Once per month
Ramsey		Once per month
Gowganda		Once per month
Moonbeam		Once per month
Attawapiskat		Once every six months
Whitney		Once per month
Burwash		Once per month
Lively		Once per month
Hanmer		Once per month
Winisk		Once every four - six months
Dorion	Northwestern	Once per month
Nakina		Once per month
Ear Falls		Once every 3 months
Pickle Lake		Once every 1-2 months
Fernberg-Ely		Once per month
Lac La Croix		Once every 1-2 months
Quetico		Once per month
Forbes Township		Once or twice per month

Table 17 Summary of Cumulative Sampling Instrumentation Checks - Southwestern Region

SITE	MIC/SANG-A SERIAL #	ORIFICE HEIGHT	COLLECTOR AREA	LEVEL	KNIFE EDGE GAP mm	INSTRUMENT DELAY TIME s	INSTRUMENT SENSITIVITY Kv	SENSOR GRID CONDITION	CLUTCH ADJ. HOOD MOVEMENT	LIMIT SWITCH CONDITIONS	GASKET SEAL	HISTORICAL PROBLEMS	STORAGE GUAGE HEIGHT	STORAGE GUAGE ORIFICE SIZE cm	STORAGE GUAGE LEVEL
Mt. Forest 1181	Sangamo-A	2.5 m	-	off level 5 mm (N-S)	12	93 s	230	Good	- Clutch adj. >28 lbs - Hood movement not smooth - Rather jerky and tended to drop suddenly - Motor was making grinding noises	OK	- Poor seal on dry side	-	On Stand 110 cm	-	OK
Huron Park	Sangamo-A 116	2 m	Round 19.0 cm	off level 10 mm (N-S)	5	88 s	252	- Good	- Clutch adj. >28 lbs - Hood begins to move smoothly then jerks midway - Motor runs on for 10 sec after hood covers bucket	- Could not inspect switches because of frozen cover	- Poor seal on both wet and dry buckets - Gap could be noticed visually	- Had problems in the fall with the limit switch - It was shorting the circuit	N/A	N/A	N/A
Wilkesport 13/15	MIC 23	2 m	Round 19.1 (N-S) 19.2 (E-W)	off level 10 mm (E-W)	15	100 s	53	- Poor sensor grids - Not warm to touch and not pulsing current	- Clutch adj. 14 lbs - Hood does not move smoothly - Chain tended to skip and cause hood to jerk midway	- Had problems in past with faulty limit switch	- Good	- Has had problems with limit switch which caused circuit to short out - Seem to have power failure during every winter snow storm	1 m not on a stand	28.5 (N-S) 28.7 (E-W)	Yes

Table 17 (cont'd) Summary of Cumulative Sampling Instrumentation Checks - Southwestern Region

SITE	MIC/SANG-A SERIAL #	ORIFICE HEIGHT	COLLECTOR AREA	LEVEL	KNIFE EDGE GAP mm	INSTRUMENT DELAY TIME s	INSTRUMENT SENSITIVITY KΩ	SENSOR GRID CONDITION	CLUTCH ADJ. HOOD MOVEMENT	LIMIT SWITCH CONDITIONS	GASKET SEAL	HISTORICAL PROBLEMS	STORAGE GUAGE HEIGHT	STORAGE GUAGE ORIFICE SIZE cm	STORAGE GUAGE LEVEL
Palmerston 1101 S	MIC # 29	~2 m	Round 20.0 Wet 20.0 19.2 Dry 19.2	Yes	7 mm	72 s	170	Good	- Clutch adj. 22 lbs - Hood moves smoothly then jerks suddenly	Good	- Very poor seal - Hood was approx. 3 mm above bucket - bag not held down	- Windblown dust	82 cm on ground	29.3 cm (N-S) 28.8 cm (E-W)	off level 10 mm (N-S)
Port Stanley 10N. S	MIC # 516	2 m	Round 19.0 (N-S) 19.0 (E-W)	Yes	None	90 s	199	- Sensor grids were not warm to touch - No current to grids - Slightly black in color	- Clutch adj. 13 lbs - Good	Good	Good	- Electrical problems at least one a month - instrument shorts setting off G.F.I.C. - electrician couldn't find problem	83 cm - Not on Stand	Not Round 29 cm (E-W) 29.5 cm (N-S)	Not level off -E-W by 10 mm -N-S by 20 mm
Longwoods	Sangamo	1.9 m	19.2 cm	Yes	None -Knife Edge Missing	97 s	225	Good	Good	OK	Good				

Table 18 Summary of Cumulative Sampling Instrumentation Checks - Southeast Region

SITE	MIC/SANG-A SERIAL #	ORIFICE HEIGHT	COLLECTOR AREA	LEVEL	KNIFE EDGE GAP mm	INSTRUMENT DELAY TIME s	INSTRUMENT SENSITIVITY Ku	SENSOR GRID CONDITION	CLUTCH ADJ. HOOD MOVEMENT	LIMIT SWITCH CONDITIONS	GASKET SEAL	HISTORICAL PROBLEMS	STORAGE GUAGE HEIGHT	STORAGE GUAGE ORIFICE SIZE cm	STORAGE GUAGE LEVEL
Kaladar 40515	Sangamo-A # 520	~2 m	Buckets round but bag reduces orfice from 19 cm to 14 cm (N-S) 19.6 (E-W) 19.6	No ~1.5 cm off level (E-W)	16	100 s	197	Good	- Clutch adj. > 20 lbs - Hood moves smoothly but tends to drop suddenly going from dry side to wet side	OK	- good seal on wet side - dry side not as good - bag folded over edge		~2.5 m on stand 0.5 m above ground	20.4 cm Round	Not level off N-S by 8 mm
Smiths Falls 40615	Sangamo-A # 24	~2 m	Round 19.5 (N-S) 19.8 (E-W)	Yes	10	90 s	160	Good	- Clutch adj. 12 lbs - Hood movement sluggish	Ok	Good		2 m on stand	-	Not level
Dalhousie Mills 4071 S	Sangamo-A # 335	~2 m	Round 19.5 (N-S) 19.6 (E-W)	Yes	14	73 s	190	Good	- Clutch adj. 8 lbs - Hood tends to jerk and drop suddenly when going from one bucket to the other	- Plunger was slightly deformed & adjustable - Screw did not hit plunger properly	Good	- During winter months wet bags are "quite often" damaged and leak - Many problems with electrical installation - Sampler frequently shorts out and sets off circuit breaker	- Not on a stand	Round	Not level -off 10 mm (N-S) and 15 mm (E-W)
Railton Special Study 4021 EP 4022 EP	MIC # 30	2 m	Round 20.6 (N-S) 20.0 (E-W)	No 4 mm off level from N-S 5 mm off level from E-W	7	68 s	256	Good	- Clutch adj. > 18 lbs - Jerky motion - Hood stops midway going from one bucket to the next for apx. 15 sec - Hood loose fitting and doesn't cover bucket properly						

Table 19 Summary of Cumulative Sampling Instrumentation Checks - Central/NE Region

SITE	MIC/SANG-A SERIAL #	ORIFICE HEIGHT	COLLECTOR AREA	LEVEL	KNIFE EDGE GAP mm	INSTRUMENT DELAY TIME s	INSTRUMENT SENSITIVITY K_c	SENSOR GRID CONDITION	CLUTCH ADJ. HOOD MOVEMENT	LIMIT SWITCH CONDITIONS	GASKET SEAL	HISTORICAL PROBLEMS	STORAGE GUAGE HEIGHT	STORAGE GUAGE ORIFICE SIZE cm	STORAGE GUAGE LEVEL
Killarney SU21 S	Sangamo-A 756	~2 m	Round 19.3 (N-S) 19.3 (E-W)	No -Off level N-S 4 mm E-W 5 mm	None	100 s	330	- Very warm to touch	- Clutch adj. >22 lbs - Hood did not move smoothly and dropped suddenly - Chain for motor skipped	- Poor - Deformation on plunger	Good		On Stand ~0.50 m above ground Orifice 1.5 m above ground	Round 27.2	No
Mattawa SU31 S	Sangamo-A 762	~2 m	Round 19.2 (N-S) (E-W)	Yes	4	83 s	300	- Very warm to touch	- Clutch adj. >22 lbs - Hood does not move smoothly - Jerks a bit and drops suddenly - Hood not held in place properly (pin pops out occasionally)	Good	Good		On Stand * Operator left ruler in storage guage and it soaked up much of the oil.	Round	No -Off level 5 mm (N-S)
Uxbridge	Sangamo-A	2 m	19.7 19.8	Yes	3	109 s	290	Good	- Clutch adj. >24 lbs	Good	Good		- On wooden stand 10"	Round 28.3 28.3	Yes

Table 19 (cont'd) Summary of Cumulative Sampling Instrumentation Checks - Central/NE Region

SITE	MIC/SANG-A SERIAL #	ORIFICE HEIGHT	COLLECTOR AREA	LEVEL	KNIFE EDGE GAP mm	INSTRUMENT DELAY TIME s	INSTRUMENT SENSITIVITY K:	SENSOR GRID CONDITION	CLUTCH ADJ. HOOD MOVEMENT	LIMIT SWITCH CONDITIONS	GASKET SEAL	HISTORICAL PROBLEMS	STORAGE GUAGE		
													HEIGHT	ORIFICE SIZE cm	LEVEL
Waterloo 2021 S	MIC # 25	2 m 1.7 m above snow	Round 20.0 cm	Yes	14	90 s	120	Good	- Clutch adj. 11 lbs	Good	Good		0.8 m Not on stand	28.2 cm Round	Yes
Dorset	Sangamo-A # 4	216 cm	19.6 cm	off level 12 mm (E-W)	7 mm	80 s	174	- Grid quite hot (old one)	- Clutch adj. 15 lbs - smooth movement	Good	Good	- Loose stand			
Milton 3051 S	Sangamo-A 085	2 m	Round 19.3 cm	- No - Off level by 20 mm (N-S) and 10 mm (E-W)	- No gap	97 s	72	- Not very warm to touch	- Clutch adj. 10 lbs	Good	- Poor seal obtained because of improper bag instalment - No knife edge	- Power problems in the past with instrument shorting out Accessibility to breaker box is limited	120 cm on stand	33.2 cm (N-S) 33.1 cm (E-W)	-N-S Yes -E-W Off by 1 cm
Wilberforce	Sangamo-A # 121	204 cm	19.2 dry 20.1 wet	Yes	7 mm	70 s	283	- Good - Bird droppings on grids should be cleaned	- Clutch adj. >28 lbs	Good	Good		- 76 cm above ground - Not on stand	28.2 27.5	Okay

Table 20 Summary of Cumulative Sampling Instrumentation Checks - Northwestern Region

SITE	MIC/SANG-A SERIAL #	ORIFICE HEIGHT	COLLECTOR AREA	LEVEL	KNIFE EDGE GAP mm	INSTRUMENT DELAY TIME s	INSTRUMENT SENSITIVITY KΩ	SENSOR GRID CONDITION	CLUTCH ADJ. HOOD MOVEMENT	LIMIT SWITCH CONDITIONS	GASKET SEAL	HISTORICAL PROBLEMS	STORAGE GUAGE		
													HEIGHT	ORIFICE SIZE cm	LEVEL
Ely	Sangamo-A	240 cm	Round 19.7 cm	Slightly off E-W	No gap	70 s	310	Good	- Clutch adj. 14 lbs	Good	- Slight gap - Less than 1/8"		N/A	N/A	N/A
Dorion	Sangamo-A	210 cm	Round 19.7 cm	Yes	No gap	70 s	307	Good	- Clutch adj. >29 lbs	Good			128 cm	29.0 29.3	Yes
Lac La Croix	Sangamo-A	20 cm	20.2 cm N-S 19.7 cm E-W	Yes	Tight cap but knife edge loose	75 s	228	- Sensor grids cold - Black and cracked	- Clutch adj. 14 lbs - Hood jumpy at center of arc - Also makes grinding noise	Good	- Poor on wet side		N/A	N/A	N/A
Nakina	Sangamo-A	215 cm	19.7 cm 19.5 cm	Yes	Good About 6 mm in winter	90 s	393	- Good	- Clutch slips - Hood not smooth but jumpy	- Good - Chain may be loose	Good	- Dry bag sticks to gasket - ~2.5 cm sticks up above bucket	130 cm	28.0 28.5 cm	Yes

Table 21 Cumulative Sample Custody Timing

Site	Date Collected	Date Picked Up or Received By Technican	Date Received at Head Office	Date Received at Lab	Date of lab pH Analysis	Total Transit Time (days) until pH Analysis
WINTER						
Lac La Croix (NW)	02/03/82	09/03/83	16/03/82	18/03/82	18/03/82	16
Pickle Lake (NW)	02/03/82	11/03/82	20/03/82	15/03/82	15/03/82	13
Killarney (NE)	02/03/82	08/03/82	19/03/82	24/03/82	24/03/82	22
Wilkesport (SW)	02/03/82	02/03/82	12/03/82	16/03/82	16/03/82	14
Colchester (SW)	02/03/82	08/03/82	12/03/82	16/03/82	16/03/82	14
Golden Lake (SE)	02/03/82	05/03/82	03/03/02	10/03/82	10/03/82	8
Smiths Falls (SE)	02/03/82	02/03/82	08/03/82	10/03/82	11/03/82	9
Dorset (Central)	02/03/82	02/03/82	08/03/82	10/03/82	11/03/82	9
Uxbridge (Central)	02/03/82	02/03/82	02/03/82	04/03/82	05/03/82	3
SUMMER						
Lac La Croix*	25/05/82	25/05/82	04/06/82	08/06/82	19/07/82	25
Pickle Lake	25/05/82	29/05/82	05/06/82	08/06/82	19/07/82	25
Killarney	25/05/82	28/05/82	07/06/82	08/06/82	23/06/82	29
Wilkesport	25/05/82	26/05/82	07/06/82	08/06/82	11/06/82	17
Colchester	25/05/82	26/05/82	07/06/82	08/06/82	11/06/82	17
Golden Lake	25/05/82	22/05/82	17/06/82	18/06/82	23/06/82	29
Smiths Falls	25/05/82	26/05/82	17/06/82	18/06/82	23/06/82	29
Dorset	25/05/82	25/05/82	07/06/82	08/06/82	23/06/82	29
Uxbridge	25/05/82	25/05/82	25/05/82	26/05/82	31/05/82	6

*Not representative since the technician visited the site the day the sample was collected.

Table 22 SES Sampler Configurations

Site	Orifice Height	Orifice Shape	Level	Bag Fit	Comments
Railton	On stand 1.5 m above ground	Round 42.5 cm	O.K.	Poor bag fit - bag not flattened against walls of sampler - bag sits approx. 4 cm above bucket	
Whitman Creek	On stand ~ 1.5 m above ground	Round 45.4 cm	Off level by 1 cm (N-S) and (E-W)	Bag was not placed over edge of bucket in some spots ∴ resulting in a poor bag fit	
Wellesley	1.5 m above ground on stand 1.0 m above snow	Not Round 43 cm (N-S) 45 cm (E-W)	Yes	Good	Snow drifting near sampler
North Easthope	On stand 1.5 m above ground	Not Round 45.3 (N-S) 46.0 (E-W)	Off level by 1.0 cm	Good	
Longwoods	On stand 1.5 m above ground	Round 45.5 cm	Yes	Fair Some folds near orifice	

Table 23 Aerochem Metric Sampler Configurations

Site	Mounting Configuration	Heating of Sensor	Gasket Seal Integrity	Level	Height of Orifice (cm)
Longwoods	Properly secured	Good	Good	Good	135
Dorset	Good	Good	Fair seal, could be tighter	Good	127
Lac La Croix	Sampler on wooden bridge	Sensor didn't warm up	Dirty	Good	150 cm from bridge
Balsam Lake	Good	Good	Gasket should be replaced	Off level 1/4" to 1/2" per foot	110 cm
Raven Lake	Sampler has cross supports	Good	Good	Off level 1/8" & 3/4" per foot	122 cm

Table 24 Nipher Snow Gauge Configurations

Site	Orifice Height	Orifice Size and Shape	Level	Comments
Railton	2.5 m above ground	Not round 60.8 (N-S) 61.8 (E-W) Inside bucket yes 13.4 cm diameter	No, off level 2mm (N-S) 3mm (E-W)	Operator built a stand to improve accessibility during winter months
North Easthope	2 m above ground	Shield 67.0, Inside bucket 12.9 cm diameter	No, off level 35 mm (E-W) 50 mm (N-S)	Stand not sturdy - nipher container improperly installed - top of container sat above nipher shield
Wellesley	2 m above ground	Shield 62 cm, bucket 13.1 cm diameter	Yes	

Table 25 Standard Rain Gauge Configurations

Site	Orifice Height	Level	Cleanliness	General Condition of Gauge
Longwoods	75 cm above cut grass	Yes	Fair	Good
Dorset	56 cm from ground (cut grass)	Yes	Good	Good
Lac La Croix	156 cm from bridge	Yes	Std rain gauge very dirty	Funnel chipped and dirty. Appears that gauge is rarely cleaned
Balsam Lake	129 cm	Off level 1/4 to 1/2" per foot	Std rain gauge very dirty	Funnel chipped - would not affect sampling
Raven Lake	130 cm	Yes	Good	Good condition

Table 26 Low Volume Air Sampler Audit Checks

Site	Serial #	Model #	Covered	Filter Pack Height	Rotameter Condition	Volume Calibration x 10ℓ			Sampler Housing and Mounting	Comments
						Scale	Flow Meter	% Difference		
Smiths Falls	022	AS5	No	1.5 m	Good	80.0	82.0	-2 %	Housing on ground	
Dalhousie Mills	021	AS5	No	1.5 m	Good	20.0	21.4	-6 %	Housing mounted on Sangamo stand	- Have had problems with instrument in past - Children in neighbourhood have been known to turn low volume off
Kaladar	020	AS5	No	~2 m	Good	35.0	35.9	-2 %	Housing mounted on Sangamo stand	- Casing over filter pack cracked
Milton	018	AS5	Yes	~2 m	Good	80.0	79.0	+1 %	Housing was on ground but moved to Sangamo stand	- Ice and snow was shorting circuit, setting off the GFIC
Palmerston	009	AS5	Yes	1.2 m	Good	40.0	37.0	+7.5 %	Housing mounted on Sangamo stand	
Wilkesport	017	AS5	Yes	~2 m	Good	--	--	--	Housing mounted on Sangamo stand	- Housing covered with plastic - Tubing frozen solid to back of housing - unable to disconnect it to put mass flow meter in line - no calibration completed
Killarney	011	AS5	No	~1.5 m	Good	30.0	37.0	-19 %	Housing mounted on a stand of its own near low vol. filter pack	
Mattawa	006	AS5	No	1.5 m	Good	30.0	34.0	-12 %	Housing mounted on a stand of its own	
Dorion †		AS5	Yes	~ 2.25m	Good	19	32	-40 %	filter support mounted close to dry bucket	- hose connector cracked - should be replaced.
Nakina †		AS5	Yes	2.25	Good	33.8	40	-16 %	filter support mounted close to dry bucket	

* Based on short sampling period of 1-3 hours

† Note - possible mass flow meter error due to power supply problems.

Table 27 Event Precipitation Data Evaluation - Sept/Oct 1981
Southwestern Region

Site	Date	Comments
North-Easthope	September 3	- event type not noted on field sheet - data flagged as abnormal C.E. but vol < 50 ml - is data acceptable?
Melbourne	September 17	- improper sampling time noted by SIS (1630 hrs to 1630 hrs)
Melbourne	September 21	- SO_4 (13.7), NO_3 (2.38) and NH_4 (1.71) all high but no flags - improper sample time noted
Melbourne	October 1	- improper sample time noted
Melbourne	October 26	- volume = 190 ml; $NO_3/SO_4/Cl$ not analysed but H^+, Cu, Mg, K, Na, NH_4 were - seems to violate priorities for analysis
Longwoods	October 8	- poor ion balance flagged - Cl 1.16 (high) not flagged

Table 28 Monthly Volume-Weighted Concentrations for Southwestern Region Event Sites October 1981

Parameter	Longwoods	Melbourne	North Easthope	Wellesely
Std. Gauge	10.2	10.8	7.6	9.5
Sampler Efficiency	90	76	79	75
Volume	677	702	454	547
Conductivity	33	26	23	22
pH (Lab)	4.81	4.58	4.62	4.53
Total H^+ (mg CO_3)	0.08	0.08	0.08	0.07
$SO_4^=$	2.26	2.46	1.99	1.98
$N-NO_3^-$	0.47	0.34	0.39	0.30
Ca^{++}	0.33	0.16	0.13	0.09
Cl^-	0.24	0.15	0.08	0.14
Mg^{++}	0.05	0.02	0.05	0.02
K^+	0.16	0.02	0.02	0.01
Na^+	0.14	0.16	0.03	0.02
$N-NH_4^+$	0.33	0.25	0.30	0.27

Table 29 Summary of South Eastern Region Event Sampling - October 1981

Date	Sampling Details
Oct. 7	- CLIMAT SITES at Strathroy, London and St. Thomas surround the Melbourne site. All CLIMAT stations recorded 6 -7 mm of rain and Longwoods recorded 2.7 mm. No precipitation sample or field sheet was submitted from Melbourne.
Oct. 8	- Melbourne reported 4.4 mm rain, while no CLIMAT or other APIOS Event sites in the area observed precipitation.
Oct. 18	- All nearby CLIMAT and APIOS stations recorded rain >6 mm - None at Melbourne
Oct. 20	- Melbourne reports 7.4 mm rain - Others reported no precipitation
Oct. 21	- Longwoods and CLIMAT site >5.5 mm - Melbourne - no precipitation
Oct. 22	- All sites collected rain - Melbourne more than others.

Table 30 Results of Submissions of Duplicate Precipitation Samples

Sample Description	Conductivity	pH	Acidity mg/ℓ	Cl^- mg/ℓ	NO_3^- mg/ℓ	$SO_4^=$ mg/ℓ	NH_4^+ mg/ℓ	Ca^{++} mg/ℓ	Mg^{++} mg/ℓ	Na^+ mg/ℓ	K^+ mg/ℓ
1 Melbourne (O) 18118	40.5	4.11	4.43	0.11	0.49	4.75	0.700	0.37	0.080	0.045	0.160
Melbourne (D) 18119	40.7	4.09	5.94	0.11	0.50	4.70	0.660	0.37	0.075	0.045	0.145
2 Melbourne (O) 18120	49.9	3.94	6.17	0.10	0.55	0.465	0.460	0.03	0.020	0.015	0.015 < T
Melbourne (D) 18121	50.0	3.93	6.14	0.10	0.56	0.460	0.450	0.04	0.025	0.030	0.015 < T
3 Melbourne (O) 18122	18.0	4.64	1.86	0.04	0.23	1.45	0.294	0.13	0.025	0.030	0.015 < T
Melbourne (D) 18123	14.3	4.63	1.91	0.05	0.23	1.55	0.290	0.12	0.025	0.020	0.015 < T
4 N. Easthope (O) 18488	27.5	4.16	3.33	0.12	0.43	3.25	0.329	0.49	0.090	0.045	0.050
N. Easthope (D) 18489	27.6	4.24	3.35	0.12	0.42	3.30	0.330	0.48	0.090	0.045	0.060
5 N. Easthope (O) 18490	89.0	3.60	10.59	0.32	1.74	7.90	0.990	0.63	0.125	0.035	0.050
N. Easthope (D) 18491	90.0	3.63	10.25	0.32	1.72	7.90	1.000	0.62	0.130	0.035	0.035
6 N. Easthope (O) 18492	36.3	4.07	4.47	0.08	0.44	3.60	0.510	0.01 < *	0.005	0.015	0.010 < T
N. Easthope (D) 18122	36.0	4.05	4.55	0.07	0.44	3.55	0.510	0.01	0.005	0.020	0.015 < T
7 Wellesley (O) 18756	37.9	4.10	4.24	0.15	0.51	4.10	0.420	0.51	0.095	0.045	0.060
Wellesley (D) 18757	35.3	4.10	4.18	0.14	0.51	4.10	0.410	0.51	0.095	0.040	0.045
8 Wellesley (O) 18758	37.1	4.57	2.90	0.19	1.29	5.75	1.340	0.98	0.205	0.020	0.055
Wellesley (D) 18759	37.5	4.59	2.93	0.19	1.30	5.35	1.910	0.96	0.205	0.025	0.020
9 Wellesley (O) 18760	35.2	6.77	2.85	0.31	0.97	6.20	2.750	0.86	0.145	0.075	0.445
Wellesley (D) 18761	46.5	7.33	1.06	0.32	0.93	6.20	4.400	1.36	0.170	0.080	0.510
10 Wellesley (O) 18762	18.6	4.42	2.63	0.04	0.35	2.35	0.500	0.26	0.035	0.010 < T	0.015 < T
Wellesley (D) 18763	19.6	4.44	2.61	0.04	0.34	2.35	0.500	0.22	0.020	0.010 < T	0.010 < T

(O) - original sample
(D) - duplicate

Table 31 Results of Replicate Composite Sample Analyses

Sample Description	Conductivity	pH	Acidity mg/ℓ	Cl^- mg/ℓ	NO_3^- mg/ℓ	$SO_4^=$ mg/ℓ	NH_4^+ mg/ℓ	Ca^{++} mg/ℓ	Mg^{++} mg/ℓ	Na^+ mg/ℓ	K^+ mg/ℓ
38109	35.10	4.18	0.71	0.35	0.71	4.20	0.124	0.84	0.100	0.205	1.05
Composite			75.70								
38110	36.50	4.18	3.85	0.35	0.70	4.20	0.20	0.84	0.095	0.190	0.095
Composite			74.21								
38111	36.60	4.16	3.94	0.35	0.71	4.15	0.030	0.85	0.100	0.200	0.095
Composite			77.43								
38112	36.70	4.19	3.92	0.34	0.70	4.15	0.034	0.84	0.095	0.195	0.095
Composite			75.17								

Table 32 Results of Operator Handling of Prepared Samples

Sample Description	Conductivity	pH	Acidity mg/ℓ	Cl^- mg/ℓ	NO_3^- mg/ℓ	$SO_4^=$ mg/ℓ	NH_4^+ mg/ℓ	Ca^{++} mg/ℓ	Mg^{++} mg/ℓ	Na^+ mg/ℓ	K^+ mg/ℓ
1.Composite Sample average of 4 analyses April 2, 1982	35.7	4.27	4.39	0.36	0.69	3.90	4.60	0.765	0.100	0.237	0.068
Wellesley March 30, 1982. Comp. into SES collector	18.8	6.46	1.10	0.24	0.08	0.05	0.218	0.38	0.105	0.175	0.010
2.CSC D.I. H_2O June 9, 1982	5.90	6.76	0.82	0.02	0.01 < W	0.05 < W	0.012	0.01 < T	0.015	1.270	0.080
Balsam Lake June 12, 1982. DI H_2O	6.30	6.81	0.81	0.04	0.01 < W	0.05 < W	0.018	0.05	0.020	1.250	0.085
Raven Lake June 13, 1982. DI H_2O	8.90	7.10	0.99	0.04	0.01 < W	0.05 < W	0.014	0.02	0.015	1,320	0.080
Raven Lake June 13, 1982. DI H_2O	9.64	7.03	1.21	0.04	0.01 < W	0.05 < W	0.032	0.03	0.010	1.350	0.080
3 Charleston Lake April 23, 1982 DI H_2O	1.41	5.92	0.76	0.01	0.01 < W	0.05 < W	0.022	0.09	0.005 < W	0.015	0.010 < T
Kingston April 22, 1982 DI H_2O	1.69	5.91	0.90	0.01 < W	0.01 < W	0.05 < T	0.022	0.06	0.005	0.010	0.010 < T

Table 33 Deliberate Sample Contamination Analysis Results

Sample Descript.	Conductivity	pH	Acidity mg/ℓ	Cl^- mg/ℓ	NO_3^- mg/ℓ	$SO_4^=$ mg/ℓ	NH_4^+ mg/ℓ	Ca^{++} mg/ℓ	Mg^{++} mg/ℓ	Na^+ mg/ℓ	K^+ mg/ℓ	Al mg/ℓ	Zn mg/ℓ	V mg/ℓ	Fe mg/ℓ	Mn mg/ℓ	Pb mg/ℓ	P mg/ℓ	Cd mg/ℓ	Cu mg/ℓ	Ni mg/ℓ
Composite Blank	35.80	4.35	4.83	0.34	0.68	4.10	0.480	0.85	0.110	0.190	0.080	0.008	0.019	<0.002	0.012	0.008	<0.001 <T		0.0003 RRV	0.007 RRV	0.001 <T
Composite Blank	36.50	4.33	4.87	0.34	0.68	4.10	0.480	0.84	0.110	0.190	0.070	0.008	0.020	<0.002	0.013	0.008	0.013		0.0003 RRV	0.004 RRV	0.001 <T
Composite Blank	36.90	4.31	4.70	0.34	0.67	4.00	0.480	0.85	0.110	0.185	0.065										
Average	36.40	4.33	4.80	0.34	0.68	4.07	0.480	0.85	0.110	0.188	0.072	0.008	0.019	<0.002	0.012	0.008			0.0003	0.006	0.001
DI H O Blank	36.80	6.07	1.39	0.01 <W	0.01 <W	0.05 <W	0.064	0.01 <W	0.005	0.005 <W	0.005 <W	<0.005	<0.002	<0.002	0.022	<0.001	<0.001 <T		<0.001 <T	<0.001 <T	<0.001 <T
DI H O Blank	3.59	6.15	1.70	0.01 <W	0.01 <W	0.05 <W	0.049	0.01 <W	0.005	0.640	0.025										
Average		6.11	1.54	0.01 <W	0.01 <W	0.05 <W	0.056	0.01 <W	0.005												
Comp. In Bag & Put Finger In	35.60	4.31	4.64	0.41	0.70	4.20	0.002 <W	0.85	0.105	0.245	0.105	0.008	0.017	<0.002	0.012	0.008	0.12		0.0004 RRV	0.004 RRV	<0.001 <T
Comp. In Jar. Room Temp. 3 Day	36.00	4.32	4.46	0.34	0.69	4.20	0.549	0.85	0.110	0.200	0.070	0.007	0.014	<0.002	0.012	0.008	0.012		0.0003 RRV	0.004 RRV	<0.001 <T

Table 33 (cont'd) Deliberate Sample Contamination Analysis Results

Sample Descript.	Conduc-tivity	pH	Acidity mg/ℓ	Cl^- mg/ℓ	NO_3^- mg/ℓ	$SO_4^=$ mg/ℓ	NH_4^+ mg/ℓ	Ca^{++} mg/ℓ	Mg^{++} mg/ℓ	Na^+ mg/ℓ	K^+ mg/ℓ	Al mg/ℓ	Zn mg/ℓ	V mg/ℓ	Fe mg/ℓ	Mn mg/ℓ	Pb mg/ℓ	P mg/ℓ	Cd mg/ℓ	Cu mg/ℓ	Ni mg/ℓ
Comp. In Bag Ran Bare Hand Over Bag And Poured Sample Into Bottle	36.70	4.32	4.60	0.34	0.69	4.20	0.480	0.86	0.105	0.200	0.070	0.007	0.018	<0.002	0.013	0.008	0.012		0.0004 RRV	0.004 RRV	<0.001 <T
	36.50	4.30	4.59	0.34	0.69	4.20	0.480	0.87	0.110	0.205	0.075	0.007	0.019	<0.002	0.014	0.008	0.012		0.0003 RRV	0.004 RRV	<0.001 <T
	36.60	4.30	4.61	0.33	0.69	4.20	0.480	0.86	0.105	0.205	0.070										
Average	36.6	4.31	4.60	0.34	0.69	4.20	0.480	0.86	0.107	0.203	0.073	0.07	0.018	<0.002	0.014	0.008	0.012				
DI H_2O In Bag Ran Hand Over Bag And Poured Into Jar	2.00	5.86	2.42	0.01 <W	0.01 <W	0.05 <W	0.012	0.01	0.005	0.190	0.005 <T	<0.005	<0.002	<0.002	0.021	<0.001	<0.001 <T		<0.0001 <T	<0.001 <T	<0.001 <T
	1.73	6.22	1.19	0.01 <W	0.01 <W	0.05 <W	0.040	0.01 <W	0.005 <W	0.005 <T	0.005 <W	<0.005	<0.002	<0.002	0.013	<0.001	<0.001 <T		<0.0001 <T	<0.001 <T	<0.001 <T
Average	1.86	6.04	1.80	0.01 <W	0.01 <W	0.05 <W	0.026	0.01 <W	0.005												
Dirty Scissors Dirty Bag Transfer Comp. Into Bag	36.40	4.27	4.12	0.35	0.67	4.25	0.490	0.86	0.105	0.200	0.080	0.010	0.021	<0.002	0.013	0.008	0.012		0.0004 RRV	0.006	<0.001 <T
	36.50	4.36	4.19	0.36	0.68	4.10	0.490	0.87	0.105	0.210	0.065	0.007	0.019	<0.002	0.013	0.009	0.012		0.0003 RRV	0.003	<0.001 <T

Table 33 (cont'd) Deliberate Sample Contamination Analysis Results

Sample Descript.	Conductivity	pH	Acidity mg/ℓ	Cl^- mg/ℓ	NO_3^- mg/ℓ	$SO_4^=$ mg/ℓ	NH_4^+ mg/ℓ	Ca^{++} mg/ℓ	Mg^{++} mg/ℓ	Na^+ mg/ℓ	K^+ mg/ℓ	Al mg/ℓ	Zn mg/ℓ	V mg/ℓ	Fe mg/ℓ	Mn mg/ℓ	Pb mg/ℓ	P mg/ℓ	Cd mg/ℓ	Cu mg/ℓ	Ni mg/ℓ
Leach Outside Polyglove In Comp.	Insuff. Sample No Data	4.30	4.22	0.36	0.68	4.25	0.560	0.87	0.110	0.205	0.065	0.008	0.024	<0.002	0.013	0.008	0.012		0.0003	0.005	<0.001 <T
Leach Out-Side Polyglove In DI H_2O	1.87	5.98	0.98	0.01 <W	0.01 <W	0.05	0.018	0.02	0.005 <W	0.010 <T	0.005 <W	0.005 <T	<0.002 <T	<0.002 <T	0.021	<0.001 <T	<0.001 <T		<0.0001	<0.001 <T	<0.001 <T
Leach Cap Of Event Bottle with DI H_2O Black Metal Cap & Yellow Lining	3.45	6.77	1.01	0.01	0.01 <W	0.05 <W	0.010	0.02	0.005	0.675	0.035										
	4.29	6.83	0.90	0.01	0.01 <W	0.10	0.026	0.05	0.005	0.725	0.055										
Leach Cap Of Event Bottle With DI H_2O White Metal Cap	3.30	6.82	0.94	0.01 <W	0.01 <W	0.05 <W	0.010	0.01 <W	0.005 <W	0.640	0.025										
	3.30	6.24	1.23	0.01 <W	0.01 <W	0.05 <W	0.002 <W	0.01 <W	0.005 <W	0.645	0.030										

Table 33 (cont'd) Deliberate Sample Contamination Analysis Results

Sample Descript.	Conductivity	pH	Acidity mg/ℓ	Cl^- mg/ℓ	NO_3^- mg/ℓ	$SO_4^=$ mg/ℓ	NH_4^+ mg/ℓ	Ca^{++} mg/ℓ	Mg^{++} mg/ℓ	Na^+ mg/ℓ	K^+ mg/ℓ	Al mg/ℓ	Zn mg/ℓ	V mg/ℓ	Fe mg/ℓ	Mn mg/ℓ	Pb mg/ℓ	P mg/ℓ	Cd mg/ℓ	Cu mg/ℓ	Ni mg/ℓ
Leach Cap Of Event Bottle White Plastic	3.53	6.23	1.22	0.01	0.01 <W	0.05 <W	0.002	0.04	0.010	0.665	0.035										
	3.40	6.30	1.33	0.01 <W	0.01 <W	0.05 <W	0.002 <W	0.01 <T	0.005	0.650	0.025										
Comp.-Long Bag-Leached Into												0.008	0.024	<0.002 T	0.013	0.008	0.012		0.0003 RRV	0.004 RRV	<0.001 <T
Bag With Dirty Lab Coat On												0.008	0.019	<0.002 <T	0.013	0.008	0.012		0.0003 RRV	0.004 RRV	<0.001 <T
Comp. In Bag - Stood Over Bag & Shook Hair And Dirt From Clothing Into It	36.70	4.18	4.51	0.37	0.69	4.20	0.460	0.88	0.110	0.205	0.065	0.005	0.017	<0.002 <T	0.01	0.008	0.012		0.004 RRV	0.004 RRV	<0.001 <T
	36.60	4.24	3.99	0.37	0.70	4.30	0.470	0.87	0.110	0.210	0.070										
DI H_2O In Bag - Stood Over Bag & Shook Hair And Dirt From Clothing Into It	1.82	5.78	1.42	0.01 <W	0.01 <W	0.05 <W	0.002 <W	0.02	0.005 <W	0.005 <T	0.005 <W	<0.005 <T	<0.002 <T	<0.002 <T	0.020	<0.001 <T	<0.001 <T		<0.0001 <T	<0.001 <T	<0.001 <T
	1.45	5.53	1.59	0.01 <W	0.01 <W	0.05 <W	0.002 <W	0.03	0.005	0.010 <T	0.005 <T	<0.005 <T	<0.002 <T	<0.002 <T	0.020	<0.001 <T	<0.001 <T		<0.0001 <T	<0.001 <T	<0.001 <T

Table 33 (cont'd) Deliberate Sample Contamination Analysis Results

Sample Descript.	Conductivity	pH	Acidity mg/ℓ	Cl$^-$ mg/ℓ	NO$_3^-$ mg/ℓ	SO$_4^=$ mg/ℓ	NH$_4^+$ mg/ℓ	Ca^{++} mg/ℓ	Mg^{++} mg/ℓ	Na$^+$ mg/ℓ	K$^+$ mg/ℓ	Al mg/ℓ	Zn mg/ℓ	V mg/ℓ	Fe mg/ℓ	Mn mg/ℓ	Pb mg/ℓ	P mg/ℓ	Cd mg/ℓ	Cu mg/ℓ	Ni mg/ℓ
Leach Cap Of Event Bottle White Plastic	3.53	6.23	1.22	0.01	0.01 <W	0.05 <W	0.002	0.04	0.010	0.665	0.035										
	3.40	6.30	1.33	0.01 <W	0.01 <W	0.05 <W	0.002 <W	0.01 <T	0.005	0.650	0.025										
Comp.-Long Bag-Leached Into												0.008	0.024	<0.002 T	0.013	0.008	0.012		0.0003 RRV	0.004 RRV	<0.001 <T
Bag With Dirty Lab Coat On												0.008	0.019	<0.002 <T	0.013	0.008	0.012		0.0003 RRV	0.004 RRV	<0.001 <T
Comp. In Bag - Stood Over Bag & Shook Hair And Dirt From Clothing Into It	36.70	4.18	4.51	0.37	0.69	4.20	0.460	0.08	0.110	0.205	0.065	0.005	0.017	<0.002 <T	0.01	0.008	0.012		0.004 RRV	0.004 RRV	<0.001 <T
	36.60	4.24	3.99	0.37	0.70	4.30	0.470	0.87	0.110	0.210	0.070										
DI H O In Bag - Stood Over Bag & Shook Hair And Dirt From Clothing Into It	1.82	5.78	1.42	0.01 <W	0.01 <W	0.05 <W	0.002 <W	0.02	0.005 <W	0.005 <T	0.005 <W	<0.005 <T	<0.002 <T	<0.002 <T	0.020	<0.001 <T	<0.001 <T		<0.0001 <T	<0.001 <T	<0.001 <T
	1.45	5.53	1.59	0.01 <W	0.01 <W	0.05 <W	0.002 <W	0.03	0.005	0.010 <T	0.005 <T	<0.005 <T	<0.002 <T	<0.002 <T	0.020	<0.001 <T	<0.001 <T		<0.0001 <T	<0.001 <T	<0.001 <T

Table 34 Deliberate Contamination of Air Sampling Filters

Handling Procedure	Filter #	Teflon Filter (ug/Filter)			Nylon Filter (ug/Filter)	W40 Filter (ug/Filter)	IW41 Filter (ug/Filter)
		$SO_4^=$	NO_3^-	NH_4^+	SO_2	SO_2	SO_2
Touch filter with poly gloves	1	1.25 <w	0.25 <w	0.25 <w	3.34 <w	3.34 <w	3.34 <w
	2	1.25 <w	0.25 <w	0.25 <w	6.67 <w	6.67	6.67
	3	1.25 <w	0.25 <w	0.25 <w	0.50		6.67
Touched Entire Surface of Filter with base of hand	1	1.25 <w	0.25 <w	0.05 <w	6.67	3.34 <w	3.34 <w
	2	1.25 <w	0.25 <w	0.05 <w	3.34 <w	3.34 <w	3.34 <w
	3	2.50	0.25 <w	0.05 <w	3.34 <w	3.34 <w	3.34 <w
Touch edge of filter with bare fingers	1	1.25	0.25 <w	0.05 <w		3.34 <w	3.34 <w
	2	1.25	0.25 <w	0.05 <w		3.34 <w	6.67 <w
	3	1.25	0.25 <w	0.05 <w		3.34 <w	3.34 <w
Left filter exposed to room air for 4 hours	1				0.25 <w		6.67 <w
Blank	1	N/A			0.25 <w	3.34 <w	3.34 <w

<w Result = 0; Smallest Rounding Unit is Shown

FIGURE 1: APIOS SITE EVALUATION CRITERIA

1. Open area?
2. Obstructions?
    - buildings?
    - trees?
    - poles, towers?
3. Distance from obstructions (2 1/2 x H)?
4. Roads - do they exist?
    - how far away?
    - surface?
    - how cleaned in winter?
5. Fields nearby?
    - cultivated?
    - sprayed?
    - fertilized?
    - crop?
    - future plans?
6. Local sources nearby?
    - town city?
    - smokestack?
    - oil or gas wells?
    - industry?
    - gravel pits?
    - salt or sand piles?

Figure 1: continued

- parking lots?
- airport?
- marshes?
- fertilizer plants?
- sewage lagoons?

7. Overhead wires?
8. Buildings nearby?
    - how far?
    - power available?
    - heating method?
    - people?
9. Power?
    - amperage of service?
    - access?
    - special requirements?

10. Trench
    - type of soil
    - obstructions (eg. roads, trees, buildings)?
    - length of trench.

11. Ground cover?
    - type?
    - consistent?
    - future plans?

Figure 1: continued

12. Wind break?
13. Topography?
    - level or hilly?
    - site location?
14. Safety?
    - vandalism?
    - fence required?
15. Access?
    - to location?
    - to sampler
    - winter?

16. Land owner?
    - name and address?
    - cooperative?
    - full address of site?
    - own power supply?
    - remuneration OK?
    - future increases in instrumentation OK?

17. Operator(s)
    - land owner willing?
    - suggested alternative operators?
    - how far from site?
    - special requirements (eg. weekends)?
    - name and address?
    - vehicle available?

Figure 1: continued

- suitability (smart, willing, interested, time)?
- permission to access sampler?
- commitment?
- require refrigerator?
- remuneration satisfactory?

18. Authorization?
    - who?
    - name and address?
    - special requirements?

19. Electrician and/or trencher
    - suggested name and phone number?

Figure 1: continued

APOS SITE DESCRIPTION QUESTIONNAIRE

Region:

Location of Site:

Contact for further information:

Person who would be responsible for sample collection & site supervision (if known):

COMMENTS ON SITE -

1. Local Point Sources:

   Are there any house or factory chimneys nearby? Yes ____ No ____
   If yes, then how far are they from the site? ____________ metre
   How high above ground is the emission? __________ metres.

2. Other Local Sources:

   Are there any other local sources of contamination nearby, such as road salt stockpiles, sandpiles, sewage lagoons, etc.? Yes ________ No _________. Are there any ploughed fields in the vicinity? Yes ___________ No _________. How far are these sources? ___________ metres.

3. Roadways:

   How far from the nearest road is the collector? ________________

   Is the road heavily travelled, and are there any other busy roads nearby (how far?)? ____
   ____
   ____

   Type of road surface? ____
   ____

   Is there a parking lot close by? (Is it heavily used? How far?) ____
   ____

Figure 1: continued

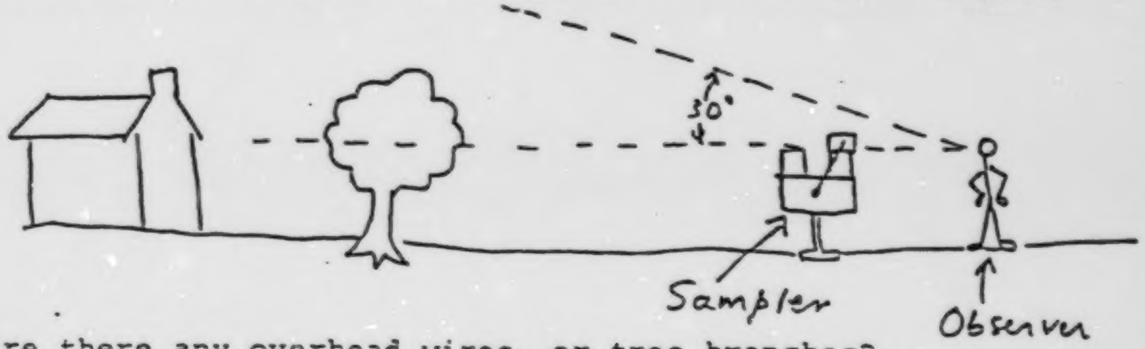
4. **Ground Cover:**

What is the immediate ground cover in the vicinity of the sampler (grassy, etc.)? ______________________________

____

5. **Obstructions:**

Are there any local obstructions, other than chimneys, projecting more than 30° above horizontal? Yes ______ No ______
If yes, please estimate projection angle at proposed sampler location and distance from sampler location (see diagram)



Are there any overhead wires, or tree branches? ____________

____

6. **Power:**

Distance to nearest available electrical outlet (metres):

____

Amperage of line: (if known) ______________________

7. **Accessibility:**

Please describe road access to proposed site (good, fair or poor):

Summer ______________________________________

Winter ______________________________________

8. **Security:**

Is the site relatively free from vandalism or possible tamperi
with the sample? ______________________________

____

Is regular (at least once per week) inspection by responsible personnel available? Yes ______ No ______

Figure 1: continued

9. Other Comments on Site:

Any cost involved for using site?

Other:

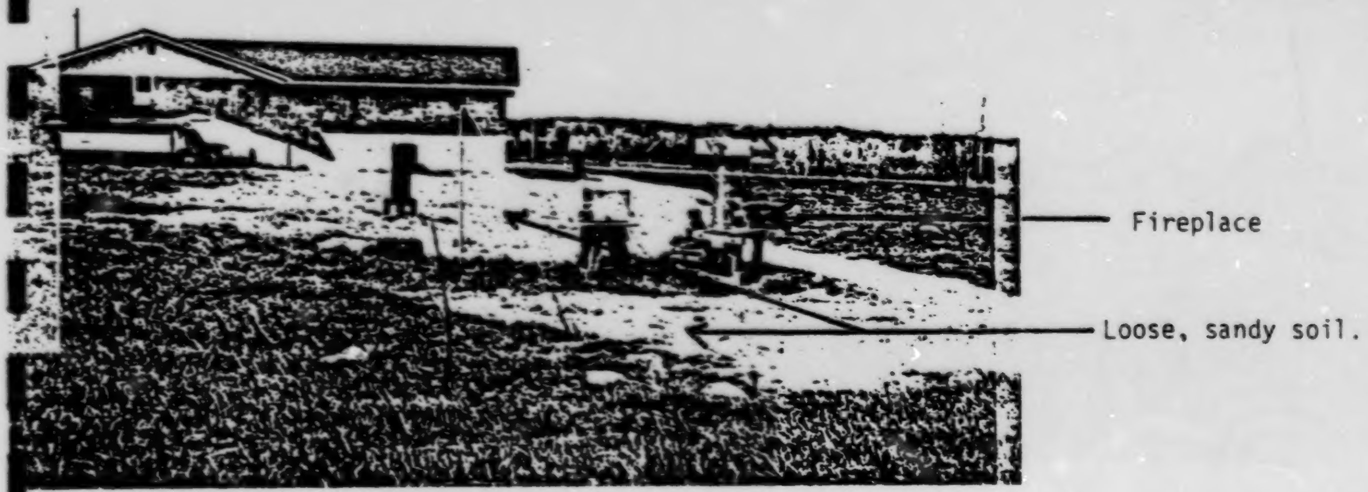

Fireplace
Loose, sandy soil.

Figure 2: Mattawa Cumulative Sampling Site

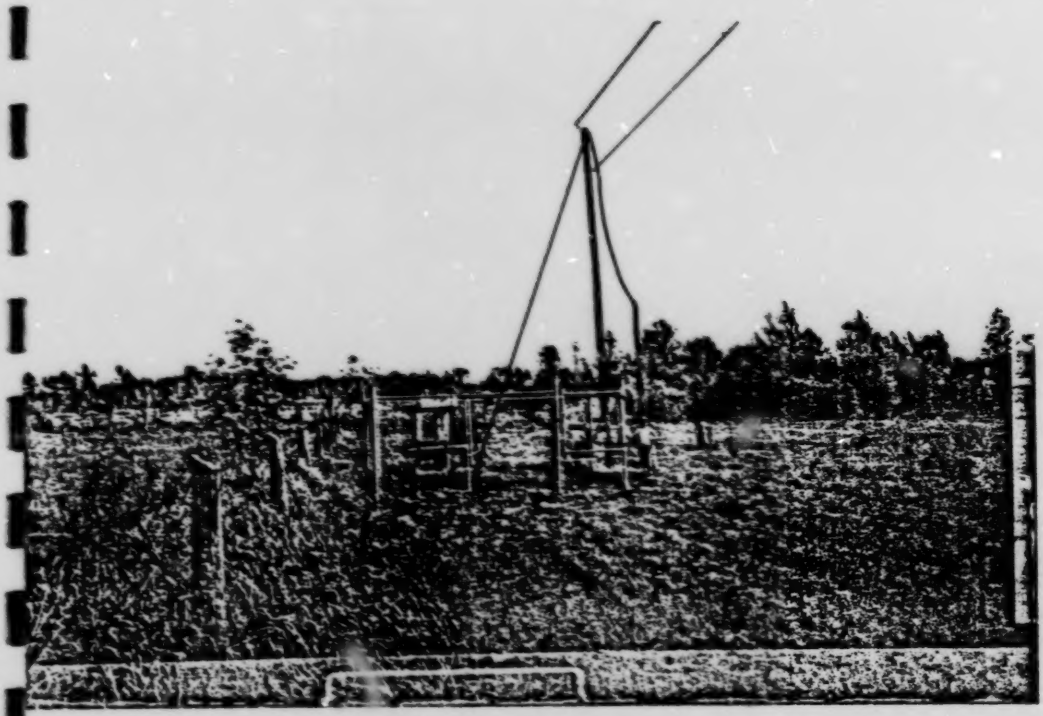


Figure 3: Smiths Falls Cumulative Monitoring Site

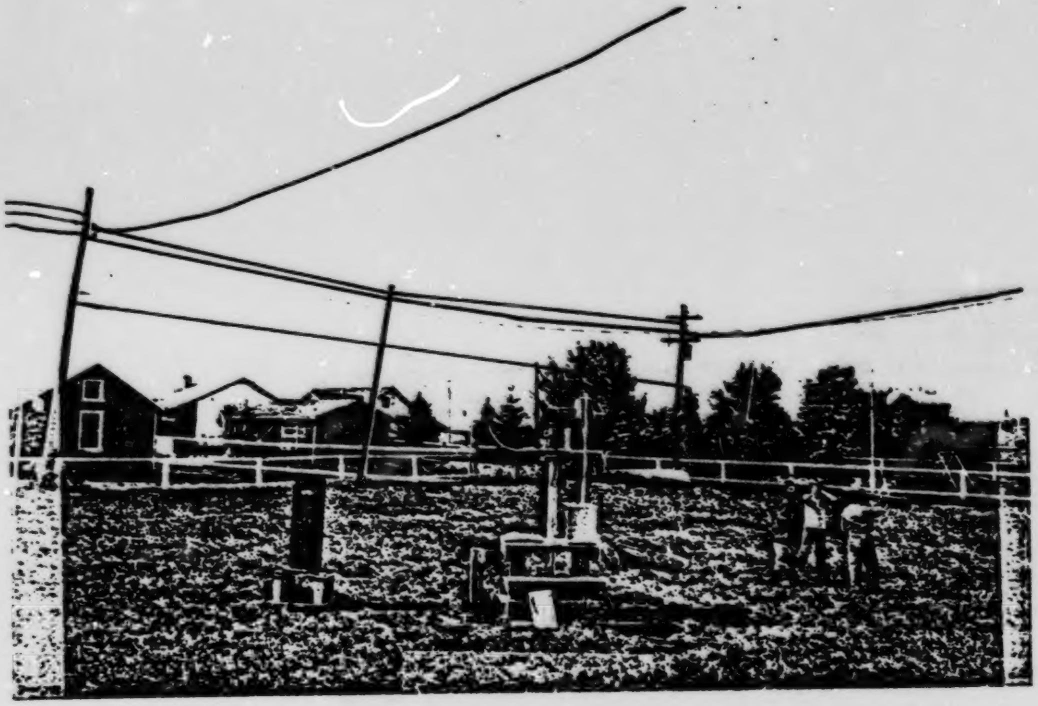


Figure 4: Nakina Cumulative Sampling Site

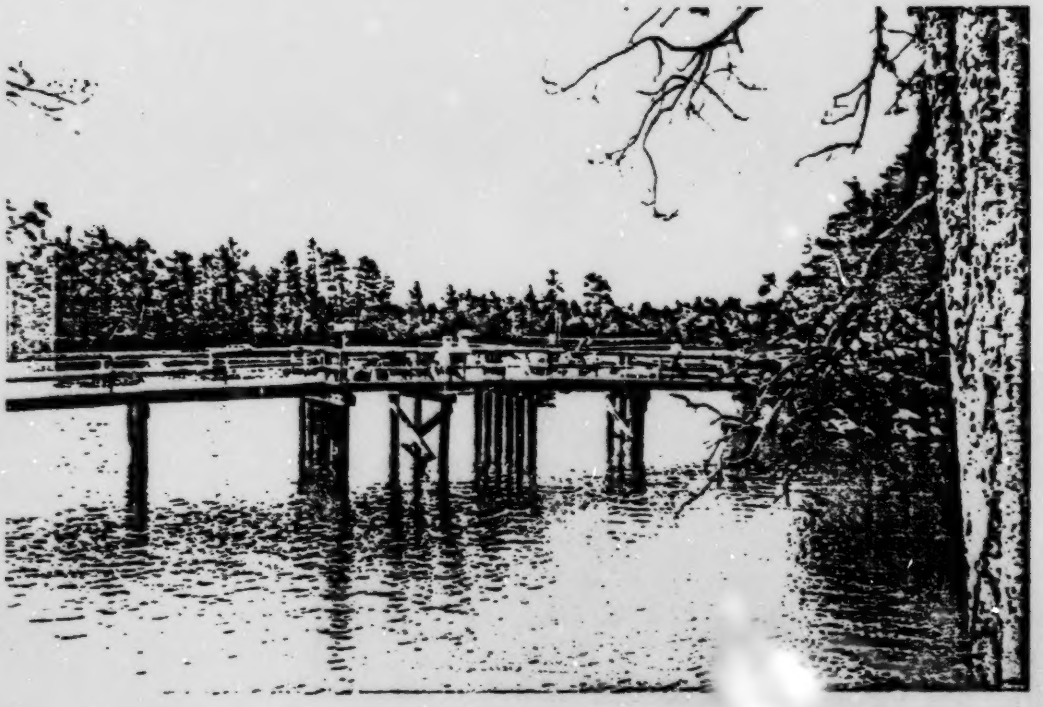


Figure 5: Lac LaCroix Cumulative and Event Sampling Site

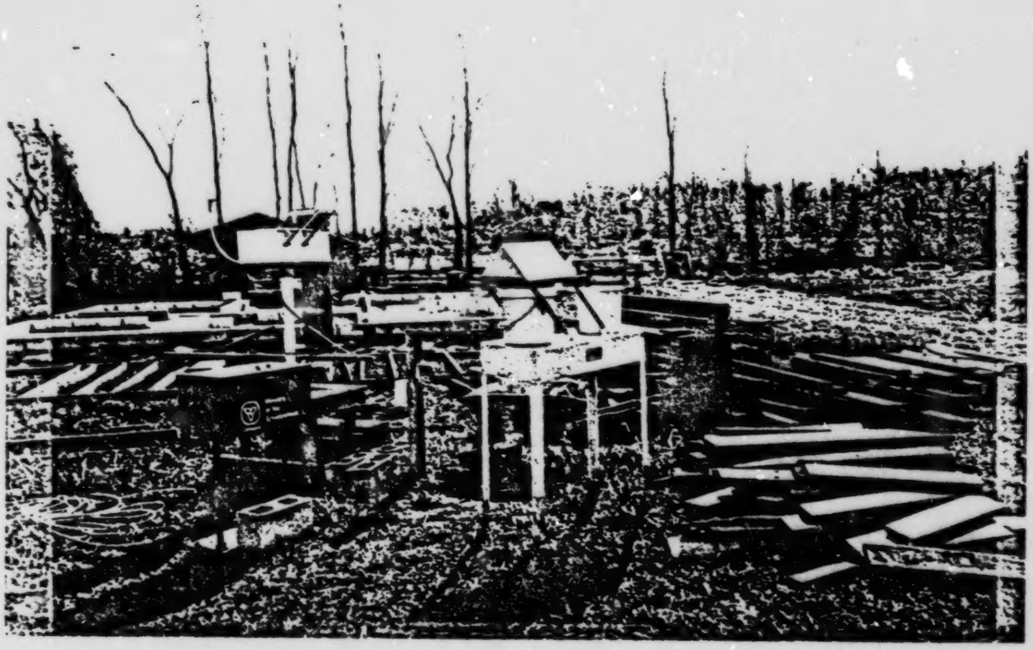


Figure 6: Railton Event Precipitation Sampling Site

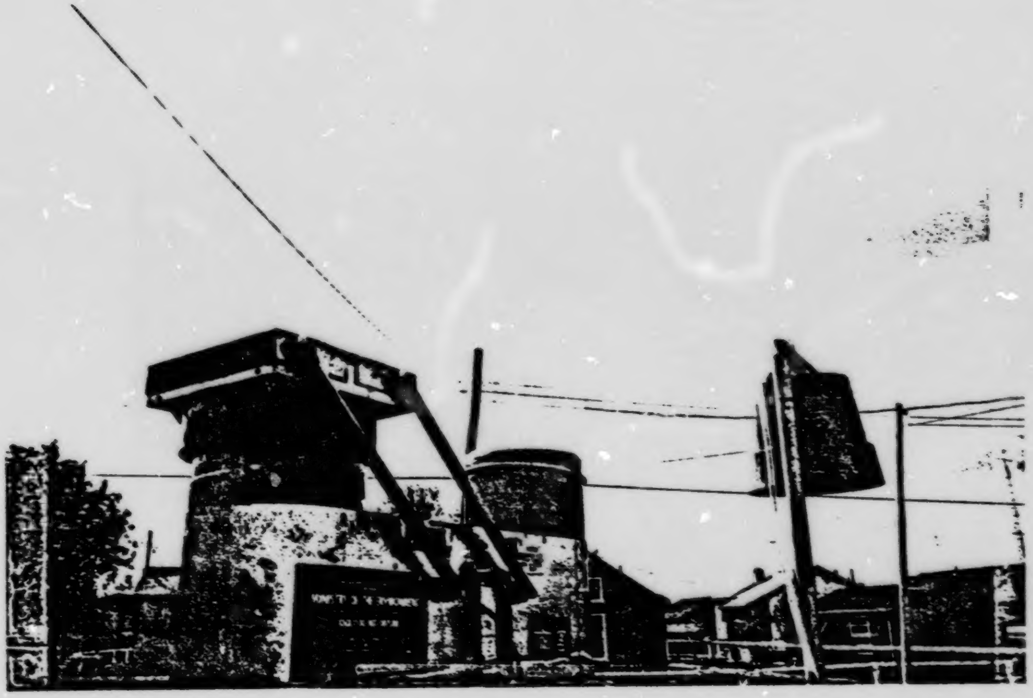


Figure 7: Typical North Western Region Low Vol Sampler Installation

Figure 8 Summary of APIOS Data Handling Procedures

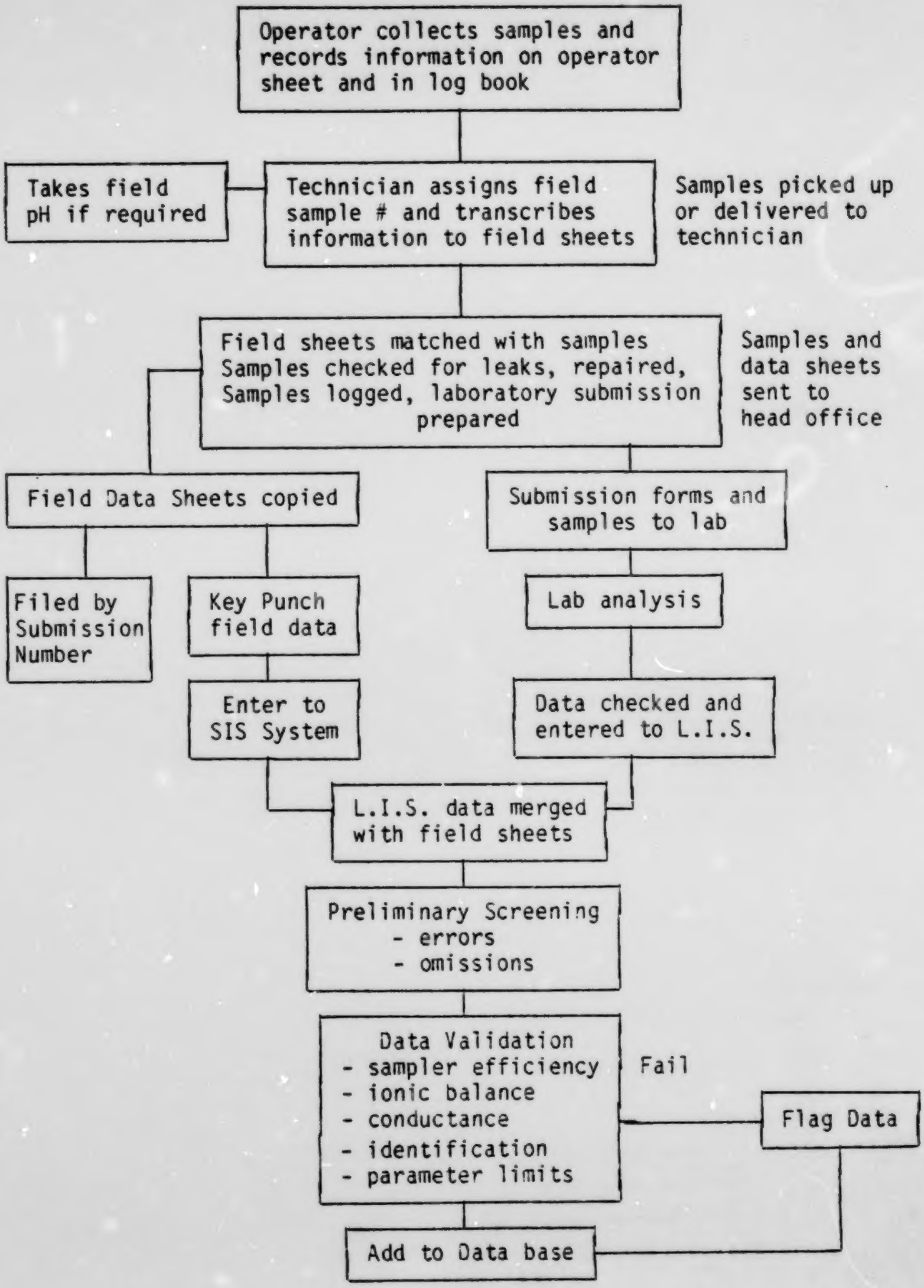
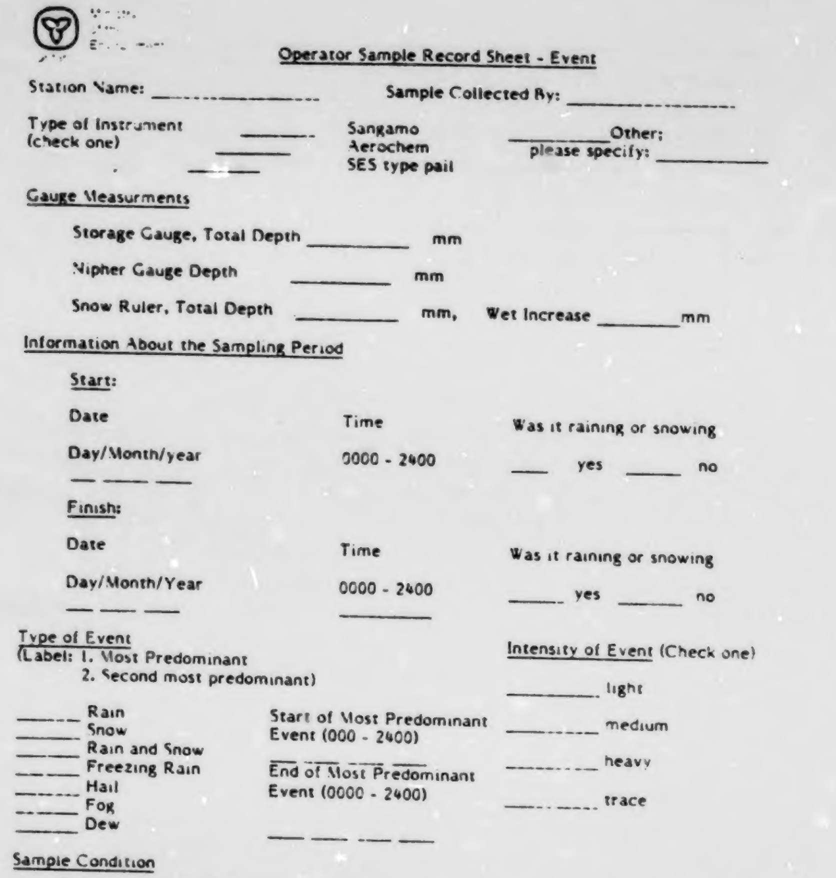

Operator collects samples and records information on operator sheet and in log book
Takes field pH if required
Technician assigns field sample # and transcribes information to field sheets
Samples picked up or delivered to technician
Field sheets matched with samples Samples checked for leaks, repaired, Samples logged, laboratory submission prepared
Samples and data sheets sent to head office
Field Data Sheets copied
Submission forms and samples to lab
Filed by Submission Number
Key Punch field data
Lab analysis
Enter to SIS System
Data checked and entered to L.I.S.
L.I.S. data merged with field sheets
Preliminary Screening - errors - omissions
Data Validation - sampler efficiency - ionic balance - conductance - identification - parameter limits
Fail
Flag Data
Add to Data base

Figure 9 Event Precipitation Operator Data Sheet



Operator Sample Record Sheet - Event

Station Name: ____________ Sample Collected By: ____________

Type of Instrument (check one)
____ Sangamo
____ Aerochem
____ SES type pail
____ Other; please specify: ____________

Gauge Measurments

Storage Gauge, Total Depth ________ mm

Nipher Gauge Depth ________ mm

Snow Ruler, Total Depth ________ mm, Wet Increase ________ mm

Information About the Sampling Period

Start:

Date
Day/Month/year
___ ___ ___

Time
0000 - 2400

Was it raining or snowing
___ yes ___ no

Finish:

Date
Day/Month/Year
___ ___ ___

Time
0000 - 2400
____

Was it raining or snowing
___ yes ___ no

Type of Event
(Label: 1. Most Predominant
2. Second most predominant)

____ Rain
____ Snow
____ Rain and Snow
____ Freezing Rain
____ Hail
____ Fog
____ Dew

Start of Most Predominant Event (000 - 2400)
___ ___ ___ ___

End of Most Predominant Event (0000 - 2400)
___ ___ ___ ___

Intensity of Event (Check one)

____ light
____ medium
____ heavy
____ trace

Sample Condition

Excess Volume (ml) ____

Type of Sample Collected

(Check one)

Dry (or at least. should have been)

____ Rain
____ Snow
____ Rain and Snow
____ Ice

Anything Else in Sample
(Check as many as necessary)

____ Insects
____ Leaves
____ Particles (Sand)
____ Fibres
____ Others; such as ____________

Any Problems?

Sample malfunction during Sampling Period

From: (Date and Time)
Day/Month/Year 0000 - 2400
___ ___ ___

To: (Date and Time)
Day/Month/Year 0000 - 2400
___ ___ ___ ________

Did Anything Go Wrong?

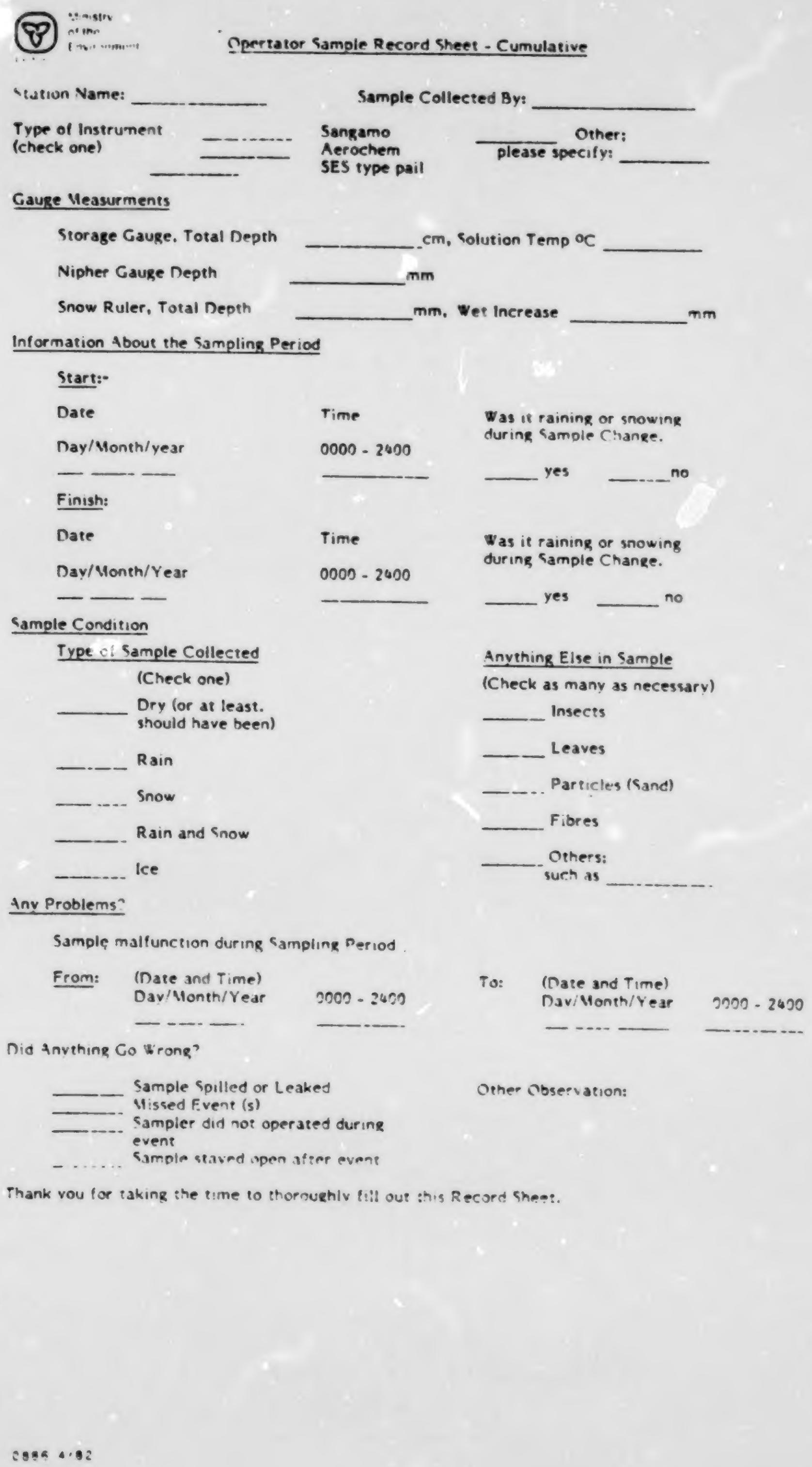
____ Sample Spilled or Leaked
____ Missed Event (s)
____ Sampler did not operated during event
____ Sample stayed open after event

Other Observation:

Thank you for taking the time to thoroughly fill out this Record Sheet.

0885 4/82

Figure 10 Cumulative Precipitation Operator Data Sheet



Ministry of the Environment

Operator Sample Record Sheet - Cumulative

Station Name: ______________ **Sample Collected By:** ________________

Type of Instrument (check one)
__________ Sangamo
__________ Aerochem
__________ SES type pail
__________ Other: please specify: __________

Gauge Measurments

Storage Gauge, Total Depth ___________cm, Solution Temp °C __________

Nipher Gauge Depth ___________mm

Snow Ruler, Total Depth ___________mm, Wet Increase ___________mm

Information About the Sampling Period

Start:-

Date	Time	Was it raining or snowing during Sample Change.
Day/Month/year	0000 - 2400	
___ ___ ___	__________	_____ yes _____no

Finish:

Date	Time	Was it raining or snowing during Sample Change.
Day/Month/Year	0000 - 2400	
___ ___ ___	__________	_____ yes _____ no

Sample Condition

Type of Sample Collected	Anything Else in Sample
(Check one)	(Check as many as necessary)
_______ Dry (or at least. should have been)	______ Insects
_______ Rain	______ Leaves
_______ Snow	______ Particles (Sand)
_______ Rain and Snow	______ Fibres
_______ Ice	______ Others: such as __________

Any Problems?

Sample malfunction during Sampling Period

From:	(Date and Time) Day/Month/Year	0000 - 2400	To:	(Date and Time) Day/Month/Year	0000 - 2400
	___ ___ ___	_________		___ ___ ___	_________

Did Anything Go Wrong?

_______ Sample Spilled or Leaked
_______ Missed Event (s)
_______ Sampler did not operated during event
_______ Sample stayed open after event

Other Observation:

Thank you for taking the time to thoroughly fill out this Record Sheet.

0885 4/82

Figure 11 Schematic For Merging and Editing Field and Laboratory APIOS Data

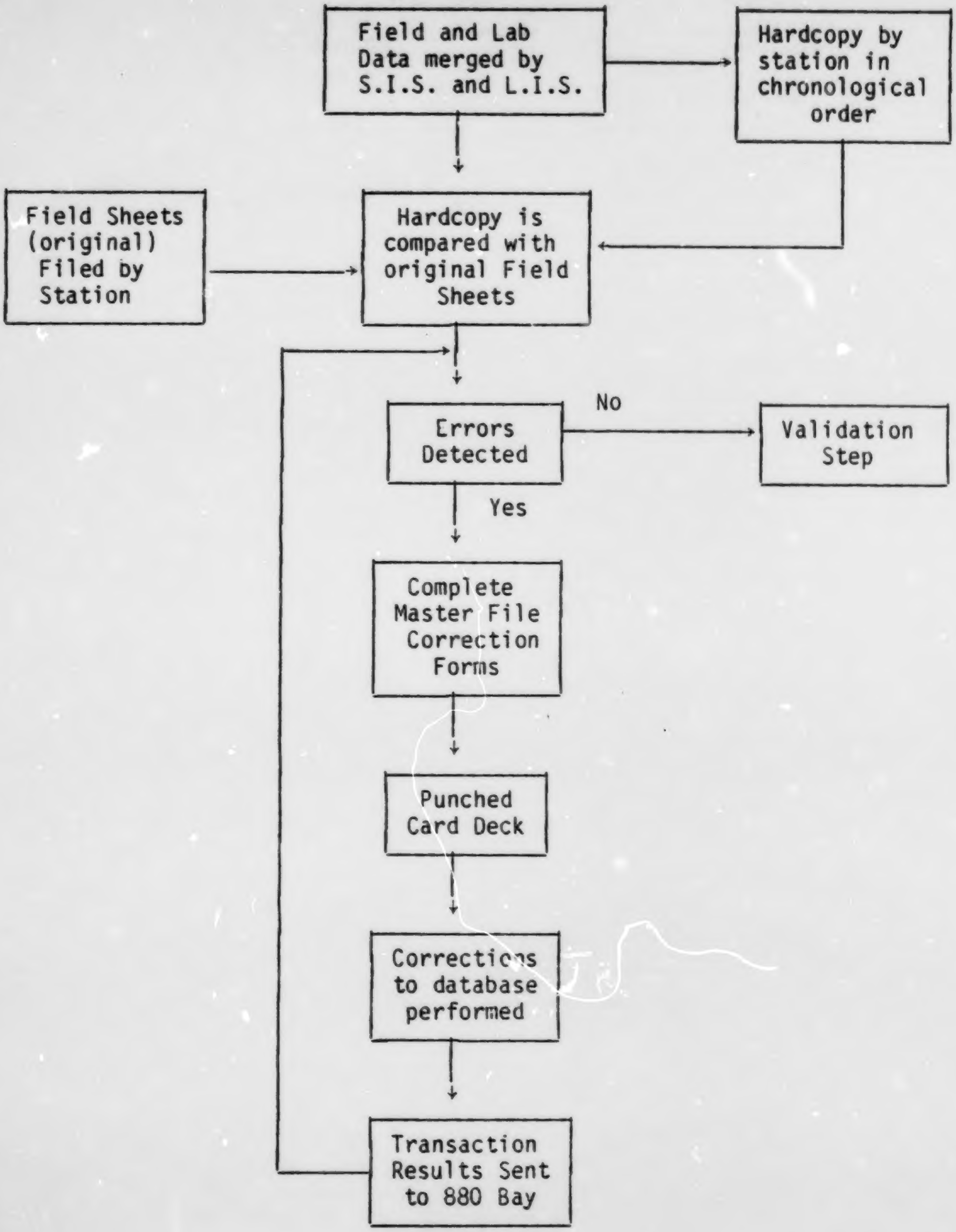

Field and Lab Data merged by S.I.S. and L.I.S.
Hardcopy by station in chronological order
Field Sheets (original) Filed by Station
Hardcopy is compared with original Field Sheets
Errors Detected
No
Validation Step
Yes
Complete Master File Correction Forms
Punched Card Deck
Corrections to database performed
Transaction Results Sent to 880 Bay

Figure 12 APIOS Data Validation Procedures Algorithm

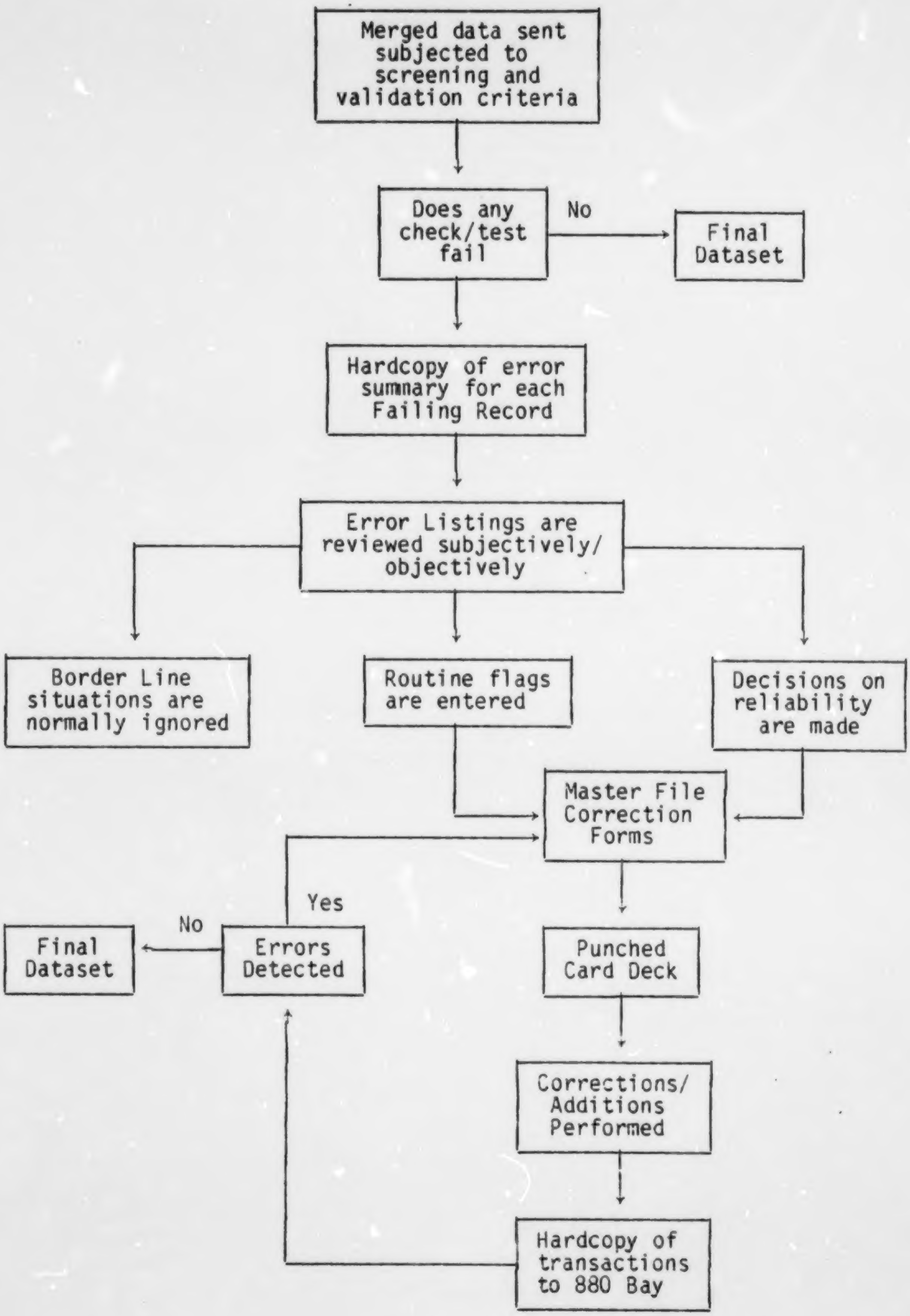
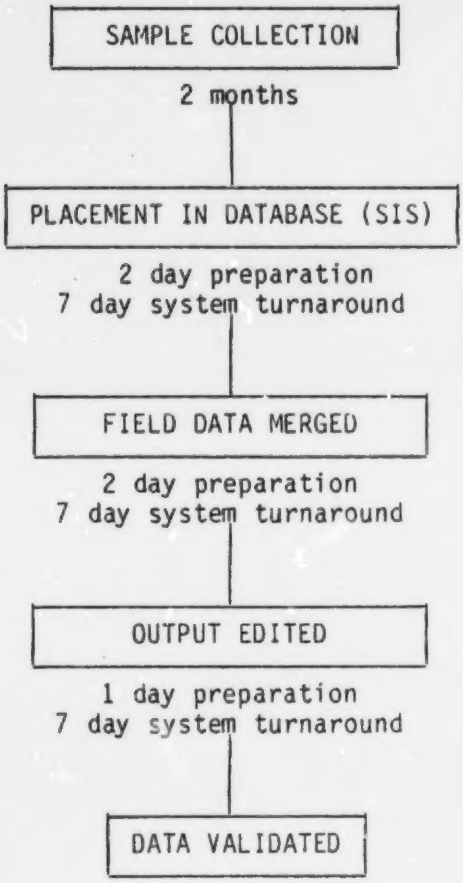
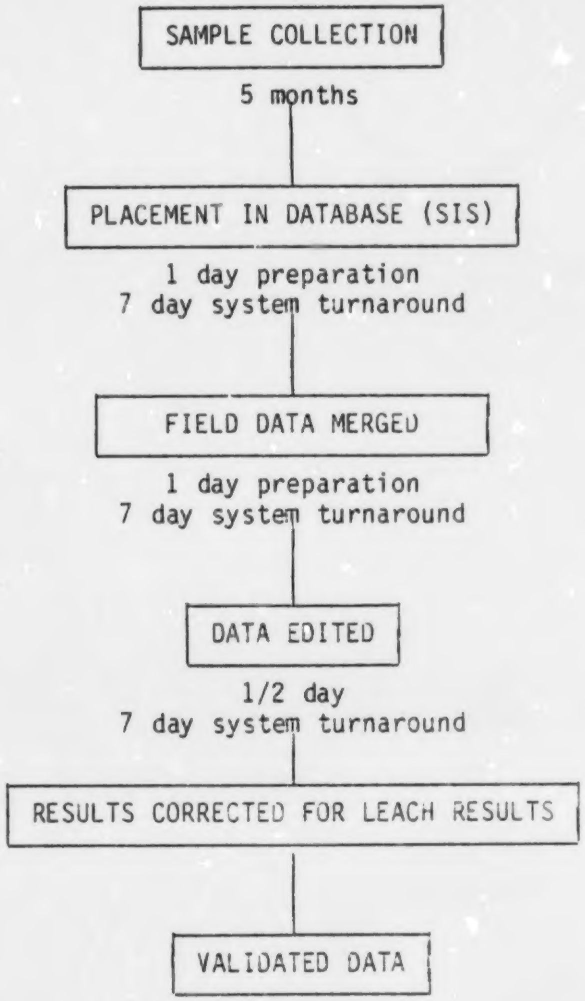

Merged data sent subjected to screening and validation criteria
Does any check/test fail
No
Final Dataset
Hardcopy of error summary for each Failing Record
Error Listings are reviewed subjectively/ objectively
Border Line situations are normally ignored
Routine flags are entered
Decisions on reliability are made
Master File Correction Forms
Yes
No
Final Dataset
Errors Detected
Punched Card Deck
Corrections/ Additions Performed
Hardcopy of transactions to 880 Bay

Figure 13 Summary of Potential Data Processing Times - Event Precipitation


SAMPLE COLLECTION
2 months
PLACEMENT IN DATABASE (SIS)
2 day preparation
7 day system turnaround
FIELD DATA MERGED
2 day preparation
7 day system turnaround
OUTPUT EDITED
1 day preparation
7 day system turnaround
DATA VALIDATED

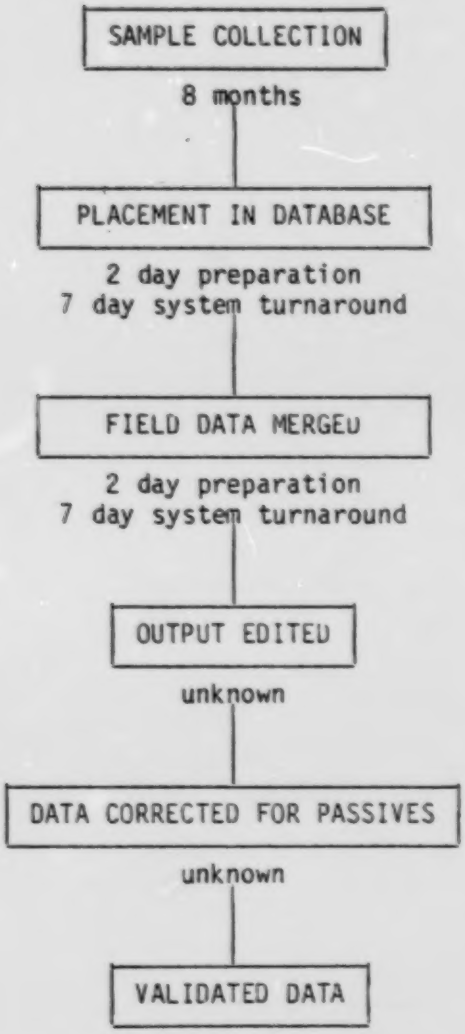
Total Time to Reporting - 3 Months

Figure 14 Summary of Potential Data Processing Times - Cumulative Precipitation


SAMPLE COLLECTION
5 months
PLACEMENT IN DATABASE (SIS)
1 day preparation
7 day system turnaround
FIELD DATA MERGED
1 day preparation
7 day system turnaround
DATA EDITED
1/2 day
7 day system turnaround
RESULTS CORRECTED FOR LEACH RESULTS
VALIDATED DATA

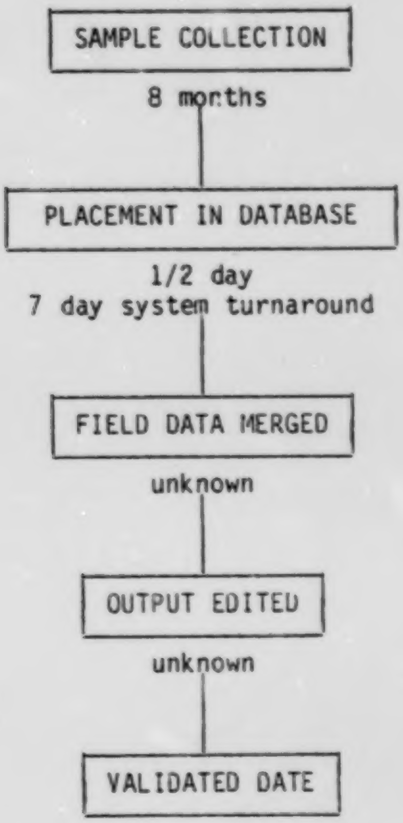
Total Time to Reporting - 6 Months

Figure 15 Summary of Potential Sample Processing Time - Daily Air Sampling


SAMPLE COLLECTION
8 months
PLACEMENT IN DATABASE
2 day preparation
7 day system turnaround
FIELD DATA MERGED
2 day preparation
7 day system turnaround
OUTPUT EDITED
unknown
DATA CORRECTED FOR PASSIVES
unknown
VALIDATED DATA

Total Time to Reporting - Unknown

Figure 16 Summary of Potential Data Processing Times - Cumulative Air Samples


SAMPLE COLLECTION
8 months
PLACEMENT IN DATABASE
1/2 day
7 day system turnaround
FIELD DATA MERGED
unknown
OUTPUT EDITED
unknown
VALIDATED DATE

Total Time to Reporting - Unknown

Figure 17 Summary of APIOS Data Processing Status - September 1982

Data Type	Collected Waiting for Analysis results	Analysis complete waiting for Editing	Editing Complete waiting for Validation	Validation complete waiting for publishing	Data Published
Event Precipitation	August 1982	Jan. - Aug. 1982			Sept. 1980 - Dec. 1981
Cumulative	April - Aug. '82	Jan. - Mar. 1982	Sept. 1980 - Dec. 1981		
Sangamo Dry Side Bags	Jan. - Aug. '82		Sept. 1980 - Dec. 1981		
Daily Air Sampling	Jan. - Aug. '82	Sept. 1980 - Dec. 1981			
Cumulative Air Sampling	Apr. - Aug. '82	Sept. 1980 - Mar. 1981			

Figure 18 Summary of Site Field Observation Forms

```
                 ONTARIO MINISTRY OF THE ENVIRONMENT
          FIELD OBSERVATION AND EFFICIENCY SUMMARY REPORT
            APIOS-ACIDIC PRECIPITATION IN ONTARIO STUDY
       ---------------------------------------------------

STATION NAME :  HAMILTON/DAILY/SANGAMO

PERIOD OF REPORT :  MAY JUNE JULY AUG SEP OCT

TOTAL NUMBER OF RECORDS ENCOUNTERED.........................   61

NUMBER OF RECORDS ENCOUNTERED WITH FIELD COMMENTS...........   13

FIELD OBSERVATIONS RELEVANT TO ALL SAMPLES (% OF RECORDS)
          INSECTS IN SAMPLE.................................  3.3
          LEAVES IN SAMPLE..................................  0.0
          PARTICULATES IN SAMPLE............................  3.3
          FIBRES IN SAMPLE..................................  1.6
          SAMPLE NOT SUBMITTED..............................  9.8
          SAMPLER MALFUNCTIONED.............................  0.0
          OTHER.............................................  0.0

FIELD OBSERVATIONS RELEVANT TO CUM. WET AND DAILY SAMPLES (% OF RECORDS)
          SAMPLE SPILLED OR LEAKED..........................  8.2
          VOLUME INCORRECT..................................  8.2
          EVENT(S) MISSED...................................  0.0
          WET SIDE OPEN WHEN NOT PRECIPITATING..............  0.0
          NO PRECIPITATION COLLECTED........................  0.0
          PART OF EVENT MISSED..............................  0.0

FIELD OBSERVATIONS RELEVANT TO CUMULATIVE DRY SAMPLES (% OF RECORDS)
          DRY SAMPLE EXPOSED WHEN PRECIPITATING.............  0.0
          DRY SAMPLE COVERED WHEN NOT PRECIPITATING.........  0.0
          WATER IN SAMPLE...................................  0.0
          WATER MARKS IN SAMPLE.............................  0.0

AVERAGE SAMPLER EFFICIENCY
          NUMBER OF RECORDS UTILIZED........................   61
          AVERAGE SAMPLER EFFICIENCY........................ 85.6%
          STANDARD ERROR OF AVERAGE EFFICIENCY..............  6.4%
```

Figure 19 Laboratory Samples Handling Procedures - Cumulative Precipitation Samples

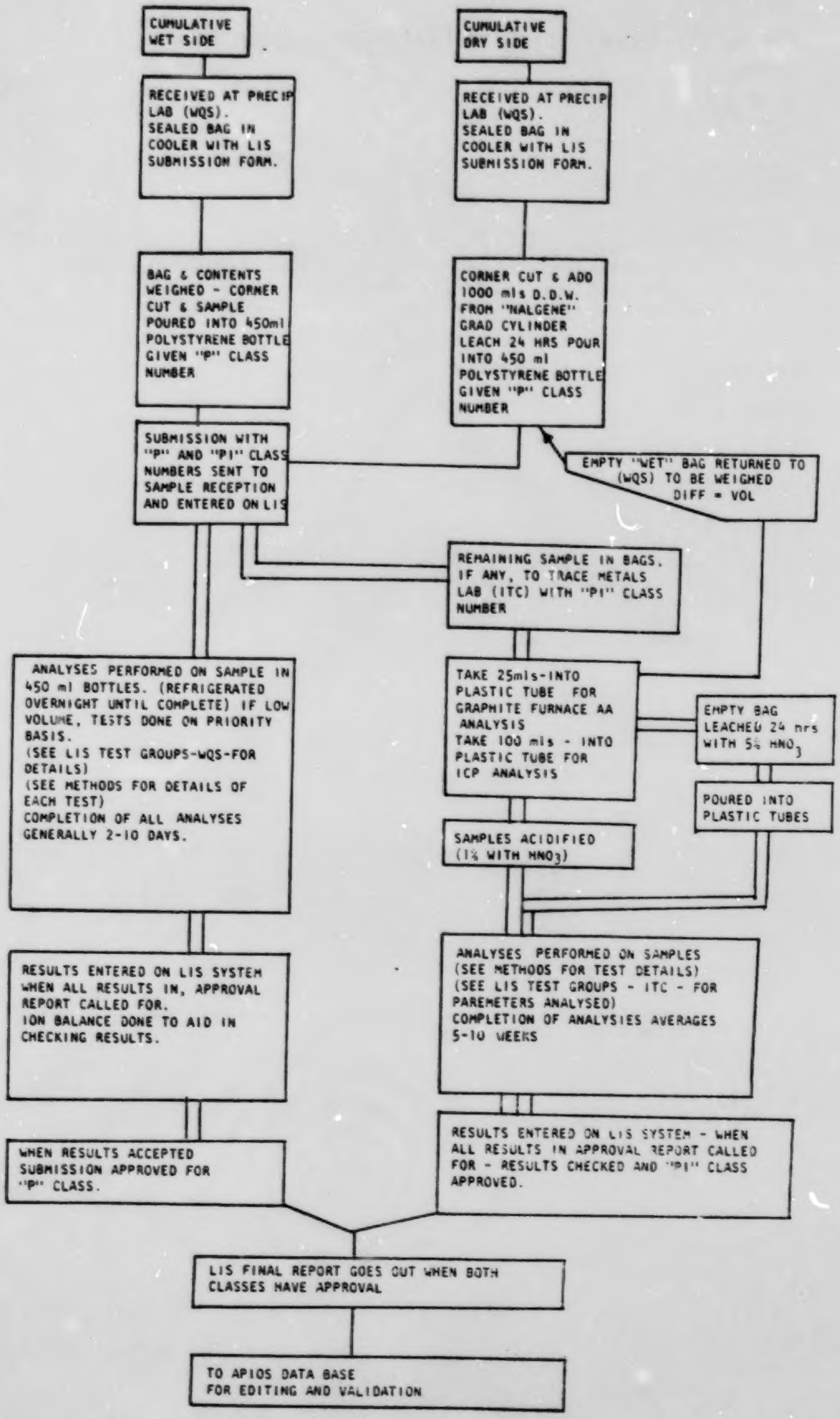
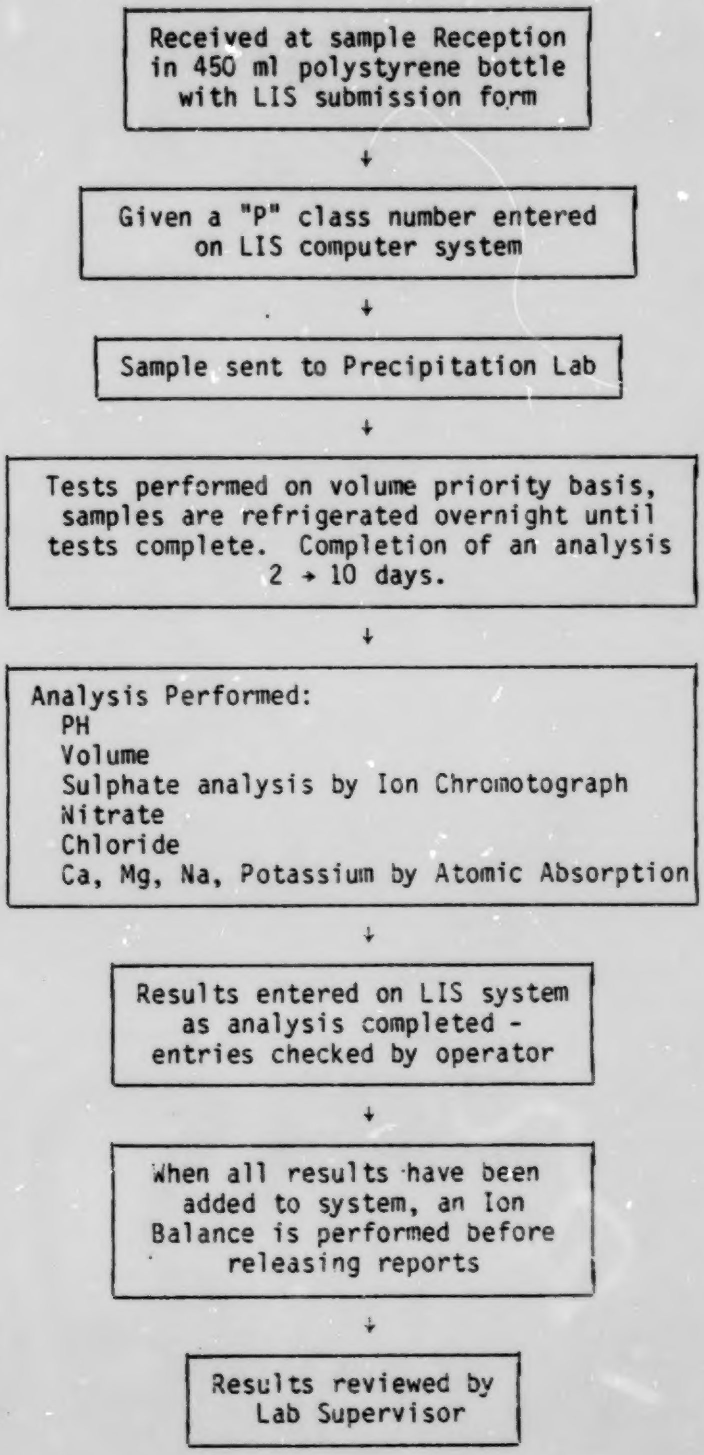

CUMULATIVE WET SIDE
CUMULATIVE DRY SIDE
RECEIVED AT PRECIP LAB (WQS). SEALED BAG IN COOLER WITH LIS SUBMISSION FORM.
RECEIVED AT PRECIP LAB (WQS). SEALED BAG IN COOLER WITH LIS SUBMISSION FORM.
BAG & CONTENTS WEIGHED - CORNER CUT & SAMPLE POURED INTO 450ml POLYSTYRENE BOTTLE GIVEN "P" CLASS NUMBER
CORNER CUT & ADD 1000 mls D.D.W. FROM "NALGENE" GRAD CYLINDER LEACH 24 HRS POUR INTO 450 ml POLYSTYRENE BOTTLE GIVEN "P" CLASS NUMBER
SUBMISSION WITH "P" AND "PI" CLASS NUMBERS SENT TO SAMPLE RECEPTION AND ENTERED ON LIS
EMPTY "WET" BAG RETURNED TO (WQS) TO BE WEIGHED DIFF = VOL
REMAINING SAMPLE IN BAGS, IF ANY, TO TRACE METALS LAB (ITC) WITH "PI" CLASS NUMBER
ANALYSES PERFORMED ON SAMPLE IN 450 ml BOTTLES. (REFRIGERATED OVERNIGHT UNTIL COMPLETE) IF LOW VOLUME, TESTS DONE ON PRIORITY BASIS. (SEE LIS TEST GROUPS-WQS-FOR DETAILS) (SEE METHODS FOR DETAILS OF EACH TEST) COMPLETION OF ALL ANALYSES GENERALLY 2-10 DAYS.
TAKE 25mls-INTO PLASTIC TUBE FOR GRAPHITE FURNACE AA ANALYSIS TAKE 100 mls - INTO PLASTIC TUBE FOR ICP ANALYSIS
EMPTY BAG LEACHED 24 hrs WITH 5% HNO3
POURED INTO PLASTIC TUBES
SAMPLES ACIDIFIED (1% WITH HNO3)
RESULTS ENTERED ON LIS SYSTEM WHEN ALL RESULTS IN, APPROVAL REPORT CALLED FOR. ION BALANCE DONE TO AID IN CHECKING RESULTS.
ANALYSES PERFORMED ON SAMPLES (SEE METHODS FOR TEST DETAILS) (SEE LIS TEST GROUPS - ITC - FOR PAREMETERS ANALYSED) COMPLETION OF ANALYSIES AVERAGES 5-10 WEEKS
WHEN RESULTS ACCEPTED SUBMISSION APPROVED FOR "P" CLASS.
RESULTS ENTERED ON LIS SYSTEM - WHEN ALL RESULTS IN APPROVAL REPORT CALLED FOR - RESULTS CHECKED AND "PI" CLASS APPROVED.
LIS FINAL REPORT GOES OUT WHEN BOTH CLASSES HAVE APPROVAL
TO APIOS DATA BASE FOR EDITING AND VALIDATION

Figure 20 Laboratory Sample Handling Procedures
- Event Precipitation Samples



Received at sample Reception in 450 ml polystyrene bottle with LIS submission form

↓

Given a "P" class number entered on LIS computer system

↓

Sample sent to Precipitation Lab

↓

Tests performed on volume priority basis, samples are refrigerated overnight until tests complete. Completion of an analysis 2 → 10 days.

↓

Analysis Performed:
- PH
- Volume
- Sulphate analysis by Ion Chromotograph
- Nitrate
- Chloride
- Ca, Mg, Na, Potassium by Atomic Absorption

↓

Results entered on LIS system as analysis completed - entries checked by operator

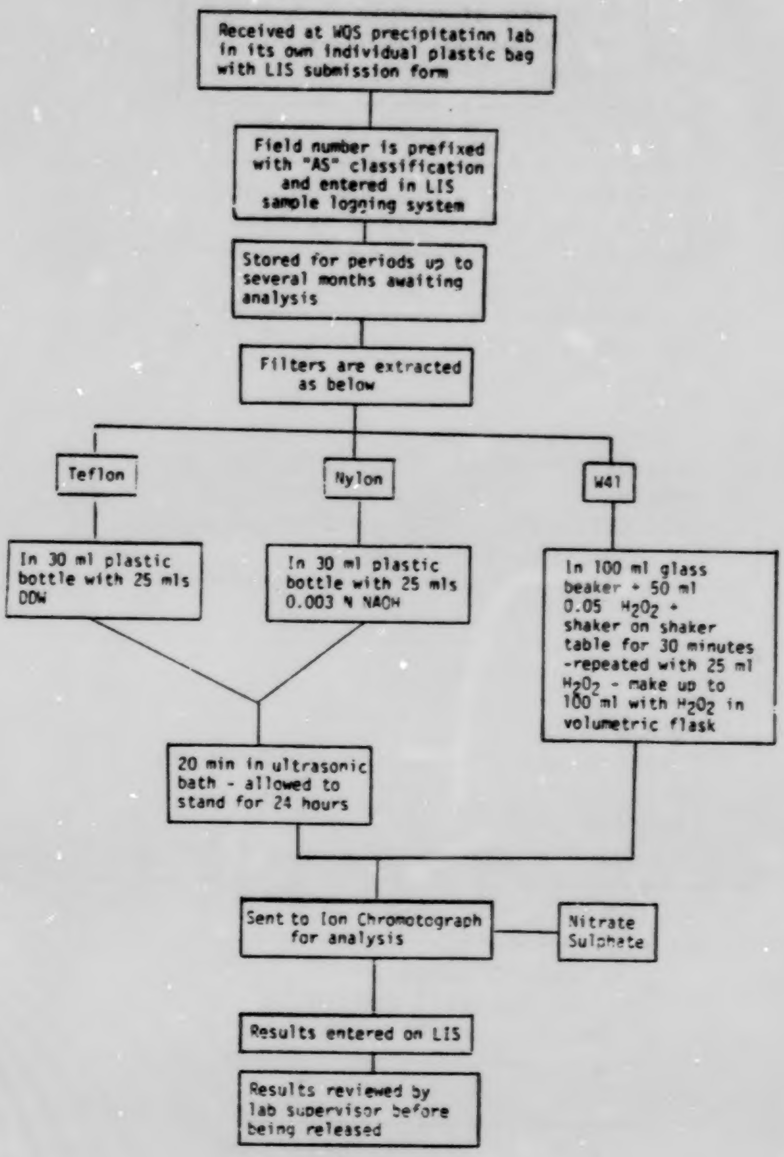
↓

When all results have been added to system, an Ion Balance is performed before releasing reports

↓

Results reviewed by Lab Supervisor

Figure 21 Laboratory Sample Handling Procedures - Air Sampling Filters


Received at WQS precipitation lab in its own individual plastic bag with LIS submission form
Field number is prefixed with "AS" classification and entered in LIS sample logging system
Stored for periods up to several months awaiting analysis
Filters are extracted as below
Teflon
Nylon
W41
In 30 ml plastic bottle with 25 mls DDW
In 30 ml plastic bottle with 25 mls 0.003 N NAOH
In 100 ml glass beaker + 50 ml 0.05 H2O2 + shaker on shaker table for 30 minutes -repeated with 25 ml H2O2 - make up to 100 ml with H2O2 in volumetric flask
20 min in ultrasonic bath - allowed to stand for 24 hours
Sent to Ion Chromotograph for analysis
Nitrate Sulphate
Results entered on LIS
Results reviewed by lab supervisor before being released

REFERENCES

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Volume 2

APPENDICES

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APPENDIX I - SITE DESCRIPTION AUDIT QUESTIONNAIRE

I-1 Site Identification
I-2 Instrumentation on Site
I-3 Logistics
I-4 Topography and Land Use
I-5 Human Activity
I-6 Site Summary
I-7 Site Location
I-8 Site Diagram and Site Pictures

I SITE DESCRIPTION AUDIT QUESTIONNAIRE

SITE:

DATE OF SITE AUDIT:

TIME:

OPERATOR:

AUDITOR:

I-1 SITE IDENTIFICATION

TYPE OF SITE

Regular APIOS Site____________ Special Study__________________

SAMPLE TYPES COLLECTED AT SITE

Cumulative Wet________________ Cumulative Dry__________________

Event Wet ________________ Event Dry __________________

Other (describe)____

Station Name__________________ Station Number (SIS)______________

MOE REGION__________________ County________ Township______________

Latitude_____° _____' _____" Longitude_____° _____' ____"Elevation ____m

UTM Co-ordinates__________________E________________N__________

Name of Primary Operator______________________________________

Alternate Operator______________________________________

Regional Technician______________________________________

Mailing Address (Primary Operator)____________________________

Phone (Primary Operator)_____/________(Res)____/________(Bus)

Phone (Alternate Operator)____/________(Res)____/________(Bus)

Nearest APIOS Site Cumulative: Station Name____________________

Distance____________________

Event: Station Name____________________

Distance____________________

I-2 LIST OF INSTRUMENTATION

1) Instrument Type: ____________________

Cumulative Wet : ________ Cumulative Dry: ________

Event Wet: ________ Event Dry: ________

Other (describe): ____________________

Manufacturer: ________ Model #: ________ Serial #: ________

2) Instrument Type: ____________________

Cumulative Wet : ________ Cumulative Dry: ________

Event Wet: ________ Event Dry: ________

Other (describe): ____________________

Manufacturer: ________ Model #: ________ Serial #: ________

3) Instrument Type: ____________________

Cumulative Wet : ________ Cumulative Dry: ________

Event Wet: ________ Event Dry: ________

Other (describe): ____________________

Manufacturer: ________ Model #: ________ Serial #: ________

1) Standard Gauge Type ____________________

2) Standard Gauge Type ____________________

Other ____________________

____

____

____

1-3 SITE LOGISTICS

1) Is road access to site in summer:____good____fair____poor?

winter:____good____fair____poor?

2) Type of road surface (dirt, gravel, oiled, paved)_______

3) How far is primary collector from road access?_________m

direction____

4) If necessary how close can a vehicle approach the collector?_______________________________________

5) If no road access to site, how is site reached? (plane, snowmobile)______________________________________

6) What is the electrical power available at site?_________

(Volts)__________(Amps)______________(No. of circuits)

7) Is the circuit on a Receptacle GFIC____________________

Circuit Breaker GFIC ______________

No GFIC ___________________________

Battery ___________________________

8) Distance from collector receptacle to circuit panel?_____m

9) What are the number of power failures per month?_________

per year?__________

10) Are there any other logistical problems which prevent the sampling site being easily approached or operated? (locked gate, guard dog, flooding in spring?)_____________

____

____

____

____

I-4 TOPOGRAPHY AND LAND USE

1) Ground slope at site:______________________________%

2) Ground cover within 15 m of sampler (grass, scrub, gravel sand, soil)______________________________

3) Soil type within 10 m of site? (Sand, topsoil, clay, rocky)

____

Soil type within 500 m of site?(Sand, topsoil, clay, rocky)

____

4) Land Use % near site, within 1 km/10 km?

% Cultivated ______________/______________________

% Orchard ______________/______________________

% Lawn ______________/______________________

% Pasture ______________/______________________

% Forest ______________/______________________

% Water ______________/______________________

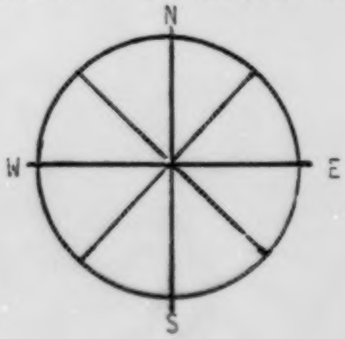
% Other (describe)_______/______________________

Type of Cultivated crop(s) ______________________

Forest types within 1 km of site?______________________

5) What types of windbreaks are within 200 m of primary sampler (buildings, trees, hills)______________________

6) Indicate any windbreaks within 200 m of primary sampler (Mark what quadrants of the compass have a windbreak)



7) Prevailing wind direction during event? (according to Operator)

Winter________________________°

Summer________________________°

8) Comment on local topography (i.e. flat, hilly, river, basin,etc.)

____

____

____

____

____

____

9) Cultivated Land Use

Type of Crop	Type of Herbicide or Insecticide Used and when Applied	Type of Fertilizers and when applied	Future Crops	Distance to crops	Direction to crops

10) Any planned future land use in Area? ____________________

____

____

11) In winter is there any evidence of drifting snow? __________

12) Tall objects near sampler:

1) Trees __________ (species) Max Height ______________ m

Distance ________ (m) Direction ______________ °

11) Buildings ________ (type) Height ______________ m

Use __________ Type of heating ________ Distance __________ m

Direction ______________ °

111) Other (overhead wires, telephone poles, hedges)

A. Object ______________ Height ______________ m

Direction ______________ ° Distance ______________ m

B. Object ______________ Height ______________ m

Direction ______________ ° Distance ______________ m

C. Object ______________ Height ______________ m

Direction ______________ ° Distance ______________ m

Comments ____

____

____

____

____

____

1-5 HUMAN ACTIVITY

1) Large highways (expressways): Distance______________(Km,m)

Route #_______________Direction from Sampler____________

2) Other paved roads: Distance__________________________(km,m)

Direction from sampler__________________________________

traffic: Heavy__________,Medium___________,Light________

3) Unpaved road: Distance________________________________(km,m)

Direction from sampler__________________________________

traffic: Heavy_________,Medium____________,Light_________

Surface (dirt, gravel, oiled)___________________________

4) Parking Lot: Distance_________________________________(km,m)

Direction from sampler____________________________________

Unpaved___________Surface material_______Use: continous___

5) Lake/river or rail traffic: Distance________________(km,m)

Direction from sampler_________barge_____________________

lake steamer____________________rail______________________

traffic: Heavy__________,Medium__________,Light_________

6) Snow clearing procedures

Type of Surface (road, parking lot, hwy, walkway)	Surface distance from Sampler (m)	Direction from Sampler	Snow Control (plowed, sanded, blown, salted-with what?)

7) Airport(s): Distance____________________(km,m)

Direction from sampler__________Name________________

traffic: Heavy_______, Medium_________, Light_________

8) Stationary sources:

Power plant(s): Distance____________________(km,m)

Direction from sampler________Fuel (gas, coal)________

Electrical Capacity_________________(KW_e, MW_e)

Light industry: Name____________ Distance__________(km)

Direction from sampler____________Product_____________

Heavy industry: Name______________Distance__________(km)

Direction from sampler____________Product______________

9) Other sources: Significant agricultural operations:

Distance______________________________________(km,m)

Direction from sampler__________Other (please describe) _

____

9) cont'd

Distance________________(km,m) Direction from sampler________

Other could include - gravel pits, sewage lagoons, marshes, MOT, Salt or Sand piles - (see Topographical Maps)

10)

Cities, Towns, Villages	A >	100,000
	B >	10,000
	C <	10,000
	D <	1,000

NAME	POPULATION	DISTANCE	DIRECTION	TYPES OF POLLUTION SOURCES

1-6 SITE SUMMARY

List deviations from siting criteria and all advantages and disadvantages of this site. (use reverse side if necessary)

1-7 SITE LOCATION

1) A topographic map (Scale 1:50,000) indicating sample site with a Red X.

   - arrows on top map indicating best approach from nearest "MAIN" Highway.

   - indicate with red dots any major sources of pollution or contamination (industry, gravel pits, towns)

2) A concise description on how to reach this site.

1-8 SITE DIAGRAM

1) Notable Items

1. North
2. Direction of Prevailing winds (precip.)
3. Windbreaks
4. Roads (with names)
5. Parking Lots
6. Buildings (indicate type of heating)
7. Potential contamination sources
8. Ground cover (grass, scrub, soil, sand)
9. Trees/hedges/marshes
10. Obstructions (include height): poles, towers
11. Topography
12. Water
13. Crops/gardens
14. Paths (foot, snowmobile, ski)
15. Location of existing hydro facilities
16. Position of sampler(s)
17. Nature of soil (rocky, sandy, clay)

2) Legend

Coniferous trees (include height, H=)

Deciduous trees (include height, H=)

Wooden fencing (include height, H=)

Wire fencing (include height, H=)

Grass

Direction of ground slope

Bushes/hedges (include height, H=)

Buildings (height and heating)

Railway tracks

Site Pictures (Indicate Site Name on back of all Prints)

1) Two pictures to be taken so as to best include all sampling instrumentation on site. If possible take pictures - 90° apart from each other.

   Indicate on Site Diagram as P1 and P2 where the pictures were taken from. Also indentify each picture on list of photographs.

2) Take four pictures showing area surrounding site. These should be taken of four compass points from just behind primary sampler facing in direction of compass points.

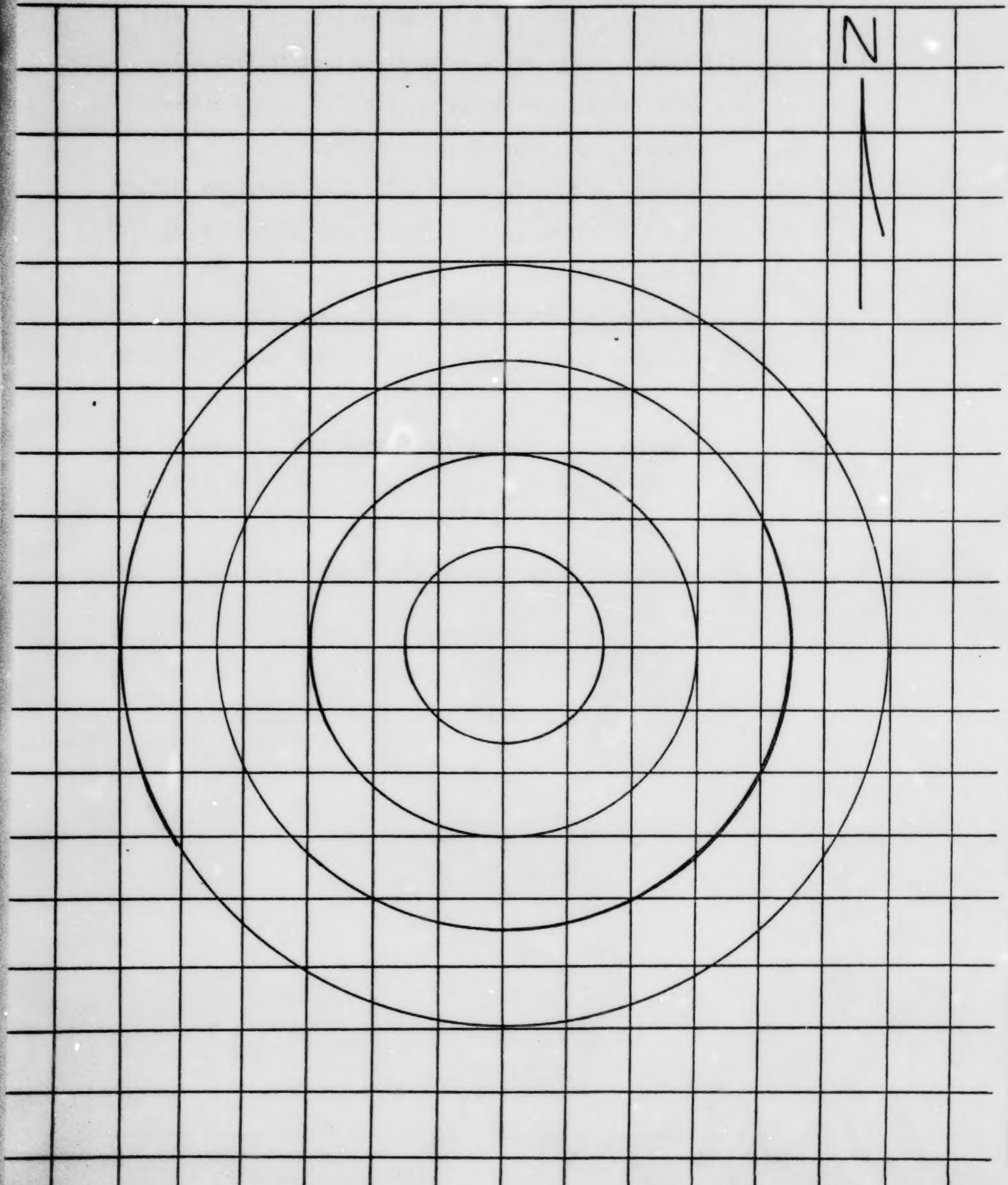
3) Any special pictures of instrumentation on site, nearby potential sources of contamination (e.g. salt pile).

   These should be indicated if possible on site diagram as SP1, SP2, etc, with a description of picture on back of print.

LIST OF PHOTOGRAPHS

#	Direction Facing	Comments

SITE MAP



APPENDIX II - CUMULATIVE PRECIPITATION AUDIT QUESTIONNAIRE

II-1	Operator Duties for Cumulative Sampler
II-2	Operator Duties for Storage Gauge
II-3	Cumulative Sampler Configuration Checks
II-4	Cumulative Sampler Instrumentation Checks
II-5	Storage Gauge Configuration Checks
II-6	Storage Gauge Information Checks
II-7	Technician Duties - Site Visits

II CUMULATIVE PRECIPITATION AUDIT QUESTIONNAIRE

SITE:

DATE OF SITE AUDIT:

TIME:

OPERATOR:

AUDITOR:

II-1 OPERATOR DUTIES FOR CUMULATIVE SAMPLER

1) What time does operator change sample bags? If he can't change at the proper time, what does he do? (phone technician, change bag when he can, contact alternate operator).

____

____

____

____

2) Does the operator, while removing the sample bag from the sample bucket, allow for any chance of contamination of the precipitation sample? Several points that may present contamination are:

- Is sample bucket removed from sampler prior to changing sample bag?
- Does the operator wear clean, new gloves to remove the knife edge?
- Does he handle only the outside of bucket and knife edge?

2) cont'd

- Is he careful not to contaminate knife edge when its taken off?

- Is bag removed in such a way as to not introduce contamination from top and outside portions of bag?
- Is operator careful not to stand directly over pail? Is there a potential for contamination by hair, coat etc?

Comments

3) Are the sample bags properly handled to prevent damage, sample loss and allow for proper handling by laboratory staff? Several points should be checked:

- Is air forced out of bag before sealing?
- Is bag tied near enough to the top so that it can be leached for metals analysis, but far enough down so that none of the contaminated surfaces are exposed to sample? How is bag tied and sealed?
- Does operator use a container to store and transport samples?
- Are bags promptly labelled (What information is recorded on label)?

3) cont'd

- For winter operation with long tube how is bag removed?
- Where does operator store sample for pick up by technician? (winter and summer).
- How long does it take the technician to come and pick up samples?

Comments______________________________

4) Are the sampler components carefully cleaned? Several points to be checked:

- Does operator clean the following before putting in new bag?

  Body of Sangamo with H_2O

  Sensor grids with H_2O and ETOH

  Outside of buckets with H_2O and ETOH

  Hood gasket with H_2O and ETOH
- Does he use new gloves and Kimwipes for above
- What is the cleaning procedure under cold conditions (NO H_2O) ______________________________

5) What problems does the operator experience with the sampler? How does he handle them? Some things that can happen:
   - Does wet sample bag get stuck in container when being removed?
   - What does operator do if this happens?
   - What procedure is followed if the bag comes out damaged?
   - How often are leaks observed in bags?
   - What does he think causes it?

____

____

____

____

____

6) In placing a new sample bag in the collector, does the operator observe the following points:
   - Are new gloves worn when touching inside of bag?
   - Is operator careful not to touch inside of bag any more than is necessary?
   - Is bag forced to bottom of container by filling with air?
   - Is operator careful not to put hand inside bag when installing it?
   - Is enough bag left over the edge to permit knife edge to hold bag?
   - Are new gloves used to flatten bag against the pail?

6) cont'd

- Is collar cleaned, rinsed and dried before replacing on container?
- Are new gloves worn for installation of DRY side bags?
- Is dry bag installed in same manner as wet bag?
- Is bag held in place with elastic - at least 2" below top, dry side only?
- New gloves to flatten bag against pail?
- Does the end result produce a well fitting bag? (smooth surface, no overhang).

____

____

____

____

7) Does the operator have a good knowledge of what he is expected to do? Specific points that the operator should be asked:

- Does operator have written instructions for procedures? Which procedures does he have?
- Does he think he was adequately trained?
- When was the last time the regional technician reviewed procedures with him?
- Does he have any particular problems with the sampling?

____

____

____

8) Does the operator have sufficient supplies on site? He should be asked:

- Does he receive regular shipment of supplies or as needed?
- Does he have enough of the following?

  Sample forms
  Bags
  DI H_2O and ethanol
  Kimwipes
  Gloves

- Has he ever run out of supplies?

9) What comments does the operator have about the programme?

- Does operator understand why he is collecting the sample?
- Does operator understand why all the special precautions? (glove, cleaning bags etc.) are required?
- Does operator get any feedback on programme?
- Would he like feedback? How often?
- Does he have any special comments with regards to the sampling, site, technician or programme as a whole?
- Does he feel the pay is adequate?

10) Does the operator check sampler performance on a regular basis?

- Does he check that hood seals tightly on wet and dry pails when reactiviated?
- Does he check that the sensor grid is warm?
- Ask him about other instrument checks that he may perform periodically?
- How often does he check the instrument?

____

____

____

11) Does the operator maintain a site log book?

- What type of information is recorded?
- How often is information recorded?
- Is a record kept of when events occurred?

____

____

____

12) Are sample submission sheets correctly and completely filled out?

____

____

13) Does the Regional Technician visit the site?

- How often?
- Does he talk to the operator on each visit, or is the sample just left at a location for pickup?
- Do the technician and operator discuss sample problems?
- Other than talk to the operator what else does the technician do on his site visits?

____

____

II-2 OPERATOR STORAGE GAUGE PROCEDURES

1) Does the operator take a storage gauge measurement?____

____

2) Does the operator check for debris in the gauge - on surface visually, and on the bottom using the meter stick?____________________

____

3) What does the operator do if there is debris in the storage gauge?____________________

____

4) Does the operator make two depth measurements and record the average?____________________

____

5) Does the operator have a thermometer present for winter time measurements?____________________

____

6) Does the operator stir the solution and take temperature measurement 3-6" below surface?____________________

____

II-3 CUMULATIVE PRECIPITATION SAMPLER CONFIGURATION CHECKS

1) Does gasket on sampler cover contact knife edge all the way around, especially on farthest position of sampler cover?____________________

2) Does sample bag fit container well especially on dry side and not act as a source of contamination to the gasket?____________________

3) Is the short bucket properly supported during summer time operation? Does the bucket seal properly?

____

4) Are the underside of sensor grids blackened or discoloured?____________________________

5) Is a galvanized support bracket used?______________

6) Have the original steel U bolts that hold support bracket to support post been replaced with stainless steel U bolts?____________________________

II-4 INSTRUMENT CHECKS - CUMULATIVE SAMPLER

NOTE: Record results on Cumulative Sampler - Data Sheet

1) Type of Check - Sensor Response

Checked by:
1. Remove one sensor grid
2. Connect test leads to the two sensing circuit sockets.
3. Using a decade resistance box determine the largest resistance that will activate the sampler.
4. Record the resistance in KΩ. The standardized resistance that the sampler should be set at is 220 KΩ.

2) Type of Check - Heating of Sensor

Checked by:
1. Measure the voltage across the two heating terminals on one sensor grid. A pulsing ACV of 5 volts should be detected. If the voltage is not pulsing, there is an instrument problem.

2) The heater can also be checked by simply feeling the sensor. The grids should feel warm to the touch, not hot or cold.

3) Type of Check - Clutch Adjustment

Checked by: Activate and stop the sampler midway (turn off switch). Place the hook of a spring gauge at the junction of the sampler arm and sampler cover. Holding the other end of the gauge (ring) turn on sampler. The arm should start to move until the gauge reads 14 lbs. at which point the instrument clutch should start to slip. Record the reading at which the clutch slips

4) Type of Check - Limit Switch Adjustment

Checked by: Activate sampler and when sample cover reaches midway, turn off sampler and unplug sampler from receptacle. Remove instrument screen and cover.

a) Depress limit switch plungers (2x) until they click and then release. Switch plungers should spring back without sticking.

b) Visually inspect switch plungers. Note any deformity of plunger. Plug sampler back into receptacle and turn sampler back on, observing angle of adjustment screw and limit switch plunger.

c) Note if adjustment screw is contacting plunger on such an angle as to damage switch.

d) Note if adjustment screw at end of travel is bending limit switch support bracket.

Necessary Equipment: None

5) Type of Check - Gasket Seal on Knife Edge

Checked by: Place a layer of clean plastic film on knife edge and allowing sampler cover to move over and compress plastic. After cover has closed pull on plastic to see if knife edge is making good contact with sampler cover.

6) Type of Check - Sampler Delay Time

Checked by: Short Sensor with metal strip (spoon, bolt, bar) and start stopwatch. Stop stopwatch when sample cover starts to return to wet side of instrument. Record time on data sheet.

7) Type of Check - Sampler Orifice Level

Checked by: Place a clean sheet of plastic over knife edge when sampler is in open position. Record distance, one end of level must be lifted to reach level. Record measurement on data sheet. (ex. 1 cm in 10 cm) Repeat 90° from first measurement.

8) Type of Check - Inspect Knife edge and measure gap.

Checked by: 1. Visually examine knife edge for damage (dents).

2. Measure size of gap in knife edge.

Record on data sheet.

INSTRUMENT CHECKS - CUMULATIVE SAMPLER - DATA SHEET

Instrument Manufacturer________________________________

Model Number________________________________

Serial Number________________________________

1. Sensor Response________________________________KΩ

2. Heating of Sensor________________pulsing ACV (yes/no)

________________________warm to touch approx.40°C(yes/no)

3. Clutch Adjustment______________________________lbs.

4. Limit Switch Adjustment

a)_______________do switch plungers stick (yes/no)

b)_______________deformity of switch plungers (yes/no)

c)_______________angle >10°

d)_______________does bracket bend (yes/no)

5. Gasket seal on knife edge_________good, fair, poor

6. Sampler delay time____________________sec.

7. Sampler Orifice Level

Amount off level________cm.in.__________cm.

2nd measure 90° from first_____cm in______cm

8. Condition of knife edge______________good/bad

Size of gap on knife edge_______________cm

Note: Record results on Data Sheet

II-5 Storage Gauge Configuration Checks

1. Storage Gauge Opening should be level. Place level across opening and measure amount one end of level must be lifted to achieve level. Repeat at 90° to first reading. Record reading (ex. 1 cm/10 cm out of level).

2. Measure the height of the orifice of the storage gauge above the ground. How is the base of the storage gauge supported? Record on data sheet.

II-6 Storage Gauge Instrument Checks

3. Type of Check - Measuring inside opening of storage with a ruler

4. Type of Check - Solution and Capping Layer

Checked by:
1. Visually note whether Meth/Ethyl Glycol solution or water is in storage gauge.
2. Note whether Motor Oil (colour - brown and murky) or Transil Oil (colour - clear) is capping layer in gauge.

5. Type of Check - Debris Floating or Sunk

Checked by:
1. Visually noting any floating debris in gauge or any debris in bottom of gauge.
2. Move metre stick in gauge to check for any sunken debris.

DATA SHEET

1. Amount off level __________cm in _____________cm
2nd measure at 90°__________ cm in _____________cm
2. Height of storage gauge orifice above ground _______cm
3. Type of support base ______________________________
4 Solution on Capping Layer.
1) Solution _____(Meth/Ethyl Glycol or water)
2 Capping Solution __________(Motor Oil or Transil Oil
5. Debris in gauge _________floating or at bottom of gauge.
Yes/No __________

II-7 TECHNICIAN DUTIES - CUMULATIVE PRECIPITATION MONITORING

1. How often does the technician visit the site?________

   ____

2. Does the technician park his vehicle upwind of the sampler? Does he leave it running?________________

   ____

3. Does he check the seal on the buckets? If there are problems, how does he fix them?________________

   ____

4. Does he check that hood delay is 1.5-2 minutes? If the delay is different what steps are taken?____________

   ____

5. Does he check inside the instrument housing? (limit switches, clutch, etc.)__________________________

   ____

6. Does he check the storage gauge? (level, no debris in gauge, etc.)______________________________

   ____

7. Does he check the level of all instrumentation? How often does he re-level instrumentation? (Spring only?)

   ____

8. Does he check the log book to ensure it is up to date and properly filled out?_______________________

   ____

9. Does he discuss the recent sampling period with the operator? How often does he see the operator?

9) cont'd

Are the samples picked up directly from the operator or from a designated pickup location?______________

____

____

10. When was the last time the technician reviewed the sampling procedures with the operator?____________

____

____

APPENDIX III - CUMULATIVE DRY DEPOSITION AUDIT QUESTIONNAIRE

III-1 Operator Duties for Cumulative Dry Deposition Sampling
III-2 Lo-Vol Air Sampler Configuration Checks
III-3 Lo-Vol Air Sampler Instrument Checks

CUMULATIVE DRY DEPOSITION AUDIT QUESTIONNAIRE

SITE:
DATE OF AUDIT:
TIME:
OPERATOR:
AUDITOR:

III-1 OPERATOR DUTIES FOR DRY DEPOSITION SAMPLES

1. Describe the procedure used by the operator in handling filter packs. Does he do the following?
   - handle filter packs only by using a plastic bag?
   ____
   - how are the filter packs identified, on the bag or on the filter pack?______________
   - where are the filter packs stored?__________
   ____
   ____

2. What information is recorded on data sheets?
   - flow rate - start and finish?__________
   - volumetric reading?______________
   - time of filter pack changeover?__________
   - any operator comments? __________
   ____
   ____
   ____
   ____
   ____

3. What training did operator receive on the sampler and handling filter packs?________________________

- has he been retrained since?____________________

- does he feel training was adequate?_____________

____

____

III-2 LO-VOL AIR SAMPLE CONFIGURATION CHECKS

1. Are the sampling line and tower in good condition?

____

- any kinks in the suction line?___________________

- is the tower leaning at all?______________________

- is the tower firmly supported and steady?________

____

____

____

2. Is the Lo-Vol sample protected from weather?_____

____

- by a rigid shelter?_____________________________

- by a plastic bag?_______________________________

____

3. Is the filter sampling shelter located so as not to be influenced by other nearby samplers or objects? _______

- precipitation sampler?__________________________

- trees or bushes?________________________________

- hydro posts_____________________________________

____

4. Is there any kind of deposit or black ring on the walls of the air sampler rotometer?______________

____

____

5. Is the filter pack open face level?______________

____

III-3 LO-VOL AIR SAMPLER- INSTRUMENT CHECKS

NOTE: Record Results on Data Sheet

1. Type of Check - Calibration of Rotometer

Checked by: Turn off Lo-Vol Sampler and disconnect suction line from the back of the sampler. Place a 0-5 ℓ/min mass flowmeter (mass flowmeter should be previously calibrated using a bubble meter) in line. Turn sampler and mass flowmeter on and allow 20 minutes for warm-up. The output of the mass flowmeter should be connected to a digital voltmeter (scale 0-5 VDC). Use the flow control adjust on the sampler to perform a multi-point (10 values) calibration allowing 30 seconds per reading to allow the flow rate to stabilize. The calibration range should cover 0-5 ℓ/min.

2. Type of Check - Calibration of Volumetric Counter (Gas Meter)

Checked by: The instrument set up for calibration is the same as in the "Calibration of Rotometer" except that once the flow controller has been set to approx. 2 ℓ/min it should not be adjusted. The sampler should be run for approx. one hour with each time the volume-counter changes the time and flow rate recorded.

LO-VOL SAMPLER DATA SHEET

SITE:____________________ DATE:____________________

MANUFACTURER____

MODEL NO.:____

SERIAL NO.:____

ROTOMETER CALIBRATION

Reading #	Rotometer Reading (ℓ/min)	Voltmeter Reading (VDC)	Mass Flowmeter Reading (ℓ/min)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

2) VOLUME COUNTER CALIBRATION

Reading #	Time Minutes & Seconds	Volume Reading (ℓ X10)	Volt-Meter Reading (VDC)	Mass Flowmeter Reading (ℓ/min)
1	0' 0"		0.0	0.0
2				
3				
4				
5				
6				
7				
8				
9				
10				

APPENDIX IV - EVENT PRECIPITATION AUDIT QUESTIONNAIRE

IV-1 Operator Duties for Winter and Summer Sampling
IV-2 Operator Duties for Standard Rain Guage
IV-3 Operator Duties for Nipher Guage Measurement
IV-4 SES Collector Sampler Configuration Checks
IV-5 SES Collector Instrument Checks
IV-6 Aerochemetric Sampler Configuration Checks
IV-7 Aerochemetric Sampler Instrument Checks
IV-8 Nipher Snow Gauge Configuration Checks
IV-9 Standard Rain Gauge Configuration Checks
IV-10 Technician Duties Site Visits

IV EVENT PRECIPITATION AUDIT QUESTIONNAIRE

SITE:

DATE OF AUDIT:

TIME:

OPERATOR:

AUDITOR:

IV-1 OPERATOR DUTIES FOR WINTER AND SUMMER SAMPLING

1. What time does the operator check the sample bag for precipitation? If the sample bag cannot be checked at the proper time, what does he do? (Phone the Regional Technician, Change the sample bag when he can or contact the alternate operator?)

   ____

   ____

   ____

   ____

2. Does the operator, while removing the sample bag from the sample bucket, allow for any chance of contamination of the precipitation sample? Several points that could lead to contamination are:
   - is the sample bucket removed from the sampler prior to changing sample bag? ____________________
   - does the operator wear clean (new) plastic gloves to handle the bag? ____________________
   - is the outside of the bag folded up allowing contamination to enter bucket? ____________________

- is the operator careful not to stand directly over sample bucket while removing sample bag? Is there potential for contamination from operator's hair, clothes etc.?

3. After the bag is removed from the sample container,
   - Is air evacuated from the bag after being removed from container?
   - Is the top of the sample bag tied?
   - How far from the top of bag is it tied?
   - What is the sample bag tied with?

4. For reloading the sample bucket:
   - in placing new bag in sample container, does operator wear gloves?
   - does the operator touch the inside of bag when loading into sample container with only new, clean gloves?

5. When the new bag is loaded in the sample bucket:
   - does the bag fit the container well?______________
   - Is there a decrease in orifice size resulting from poor bag fit? How much is the sample area reduced (10%-100%)____

     ____

     ____

     ____

6. Describe how the operator transfers the precipitation sample from the sample bag to sample bottle?
   - does the operator inspect sample bottle for flaws?____________________________________
   - does he swirl bag and contents around prior to decanting?________________________________
   - how is sample melted if partially or completely frozen?__________________________________
   - does operator pour sample directly from bag into sample bottle?____________________________
   - does he use a clean funnel?____________________
   - does he elevate one bottom corner, clean, and cut it?____
   - describe cleaning procedure of bag and scissors?

     ____
   - if sample volume exceeds bottle contents, is excess poured into graduate and measured?______________

6) cont'd

- where is the sample transfer area?______________
- is it a clean area?__________________________

____

____

____

____

7. Sample bottles should be labelled to correspond with date submission sheets:
   - what information is placed on sample label?_____
   - is label placed on cap or bottle?_____________
   - where are samples stored for pickup by technician?
   - how long are samples usually stored prior to pickup by technician?______________________

     ____

     ____

     ____

     ____

8. What information is entered on the data sheet?
   - is any information not filled out or incorrectly filled out?______________________

     ____

     ____

     ____

9. Is there a log book on site?

   - what information is recorded?______________________

   - how often is information entered into log book?

____

____

____

____

10. When was the last time technician reviewed sampling procedures with operator?

   - how often are procedures reviewed?________________

   - does the operator think procedures should be reviewed more often?______________________

____

____

____

11. Does the operator have sufficient supplies to last for one week, one month, six months? Has the operator ever run out of supplies?________________

____

____

____

____

IV-2 OPERATOR DUTIES FOR STANDARD RAIN GAUGE

1. Is the standard gauge checked each day?______________

____

2. How does the operator handle the following situation:
   - if water level (meniscus) falls between two graduated marks?______________________________

   - what is recorded if level is below 0.2 on scale?__
____

   - if there is water that has overflowed the graduated cylinder, what does the operator do?______________
____

   - what is done for freezing rain?______________
____

   - if the graduated cylinder is dirty?______________
____

IV NIPHER GAUGE MEASUREMENT

1. Does the operator have the following supplied:
   - 2 collection vessels?______________
   - calibrated volumetric?______________
   - funnel?______________
2. During the time of year when the Nipher gauge is used what does the operator do if it rains?_______
____
____

3. What procedure is followed if sample volume exceeds graduated cylinder volume?______________
____
____
____
____

IV-4 SES COLLECTOR SAMPLER CONFIGURATION CHECKS

1. Is the support stand steady and free of snow and ice?

____

____

2. Is the sampling bucket securely attached to the stand?

____

____

3. Is sampling bag properly shaped within bucket and securely held down?__________________________

____

IV-5 SES COLLECTOR INSTRUMENT CHECKS

1. Place a clean plastic sheet over sampling orifice and measure the deviation off level.

__________cm in___________cm

2nd measure at 90° __________cm in___________cm

2. What is the average diameter measure of the collector orifice?__________________________________

____

3. What is the height of the sampling orifice above the ground cover?______________________________

____

IV-6 AEROCHEMETRICS SAMPLER CONFIGURATION CHECKS

1. Because of the large surface area and high centre of gravity of the collector the Aerochemetric can be blown over by wind. Is the collector on site securely anchored to the ground? either by:

1) cont'd

- stakes and cables? ____________
- angle iron attached to legs and into ground? ____________
- weighting of legs? ____________
- cross pieces attached to legs? ____________

____

____

2. Is the sampling orifice level?

____ cm in ____ cm

2nd reading at 90° ____ cm in ____ cm

IV-7 AEROCHEMETRICS INSTRUMENT CHECKS

1. Type of Check - Heating of Sensor

Checked by: 1) When sampler is not activated sensor should be cold to the touch. When activated, the sensor should get hot until activating precipitation evaporates.

-is the sensor warm when not activated? ____________

-is the sampler hot to the touch when activated? ____________

2. Type of Check - Cover Seal Integrity

Checked by: 1) A thorough visual inspection of cover seal checking for:

a) any holes in polyethelene gasket cover ____________

b) Any signs of gasket foam crumbling

____

[illegible] Corporation

2b) cont'd

c) any moisture on inside surface of polyethelene____________

IV-8 NIPHER SNOW GAUGE CONFIGURATION CHECKS

1. Height of collector orifice to ground____________cm
2. Pour premeasured 200 ml. of water into calibrated graduate. What does graduate read?____________

____

NOTE: 200 ml of water corresponds to an event of 15.8 mm

IV-9 STANDARD RAIN GAUGE CONFIGURATION CHECKS

1. Height of collector rim to ground____________cm
2. Height of collector rim to top of grass____________cm
3. Any cracks in funnel or graduate?____________
4. Is the graduate clean?____________

IV-10 TECHNICIAN DUTIES - SITE VISIT

1. How often does the technician visit the site?

   ____

2. Does the technician park his vehicle upwind of the sampler? Does he leave it running?____________
3. Does the technician check the aerochem:

   Sensor____________

   Gasket Integrity____________

   Gasket Cleanliness____________

   Sample bag fit in container____________

   Gasket seal____________

   On each visit?____________

   ____

4. How often is the operator checked for operating procedures and retrained?______________________________

____

5. How are the samples transported to the laboratory from field site? (boxes, coolers with ice packs etc.)

____

6. At the laboratory are the samples weighed? On what type of scale?____________________________________

7. When is the field sample number affixed to the sample bottle? At field site, regional lab or in Toronto?

____

8. How often are supplies brought to the operators, weekly, monthly, yearly? Are they brought out on demand or according to some schedule?_______________________________

____

____

APPENDIX V - EVENT DRY DEPOSITION AUDIT QUESTIONNAIRE

V-1 Operator Duties for Event Dry Deposition Sampling

V-2 Sequential Air Sampler and Sampling Boom Configuration Checks

V-3 Sequential Air Sampler and Sampling Boom Instrument Checks

V EVENT DRY DEPOSITION AUDIT QUESIONNAIRE

SITE:

DATE OF AUDIT:

TIME:

TECHNICIAN-OPERATOR:

AUDITOR:

V-1 OPERATOR DUTIES FOR EVENT DRY DEPOSITION SAMPLING

1. Describe operators procedures prior to lowering the boom? Does he do the following:
   - field sheet prepared for each filter pack or tower?____
   - are sampling channel flows transferred to data sheet?___
   - is the time showing on mechanical clock correct?________
   - is the flow rate checked?______________________________
   - is the sampler turned off before the boom is lowered?___

2. After the boom has been lowered, describe the procedure used to reload filter pack. Is the following done:
   - is a new clean sample bag used to remove filter pack?___
   - what type of bag is used?______________________________
   - are either the filter packs or bags labelled corresponding to sample channel? If not how are the filter packs identified?______________________________

2) cont'd

- is the filter pack sampling for that day transferred to another sampling channel? What channel?____________
- is the sampler turned off while filter packs are being removed?____________________________________

3. Describe procedure used to reload filter packs. Is the following done:
   - is the filter pack installed on tower while still in bag or is it removed by hand and then installed?__________
   - when are the sampling channels zeroed?_______________
   - is the sampler restarted when the boom is on the ground or after being raised?______________________
   - does the technician cycle through all channels after sampler is restarted?__________________________

4. What information is recorded on the sample sheets and in the site log book?__________________________

5. How frequently is the sampler checked, daily, weekly? Who does the checking the technician or someone else?

____

____

____

6. At the laboratory how long do the filter packs usually sit before being unloaded? ________________________

____

7. Does the technician unload filter packs in a:

- laminar flow chamber? ________________________
- fume hood? ________________________
- office? ________________________
- laboratory? ________________________

8. Are there any exposed contaminants in filter processing area?

- anyone smoking nearby? ________________________
- any exposed chemicals - especially H_2SO_4 or HNO_3? ___
- is the area generally clean or dirty? ______________

____

9. What kind of work surface does the technian use?

- teflon coated table top? ________________________
- lab bench? ________________________
- lab bench with plastic on top? ________________________
- office desk? ________________________

____

10. Is the technician's system for labelling bags easily understandable and logical? (describe the system used)
    - is it done all at once prior to unloading any filter pack?______________________________
    - is it done as filter packs are unloaded?____________

____

____

____

____

11. Describe the procedure used for handling the filters? Are the following points observed:
    - are teflon tweezers used for filter handling?_________
    - are tweezers stored in methanol prior to use?_________
    - are they wiped with new Kimwipe before touching filters?___
    - are separate tweezers used for impregnated and unimpregnated filters?_____________________________
    - are Nylon and Impregnated W41 filters folded twice before placement in sample bags? ___________________________
    - are gloves worn during filter pack unloading?_________

____

____

____

____

____

____

12. Describe the procedure used for the washing and drying of filters? Is the following done:

- Where are filter samples stored after unloading from filter packs? ______________________________
- Are filter packs completely disassembled prior to washing? ______________________________
- Are the filter packs rinsed after washing? What rinses are used? ______________________________
- How many of each type of rinse are performed? ________
- How are the filter packs dried? If air dried, are they covered during drying? What covering is used? ___
- If dried in an oven, how long, what oven temperature?

  ____
- Are the filter packs used after drying? If not, how are they stored? ______________________________

  ____

  ____

  ____

  ____

  ____

13. Describe the procedure used for reloading of filter packs. Is the following done:

- Does the technician clean off the area where filter packs will be loaded? ______________________________
- Is the work surface a lab bench, Teflon overlay board, "Kimwipes" over lab bench or other area? ____________

13) cont'd

- Are cleaned tweezers kept in separate breakers - one for unimpregnated and one for impregnated filters?
- When removing filters from bag does technician push his hand into bag or only tweezers?____________________
- When placing collar on filter pack is technician careful not to get hand near open exposed face of filter?____________________
- Is the inlet of the filter pack checked to ensure the O-ring has not failed?____________________
- Is the loaded filter pack numbered and stored in a new "Zip-loc" or "Whirl-pak" bag?____________________
- How are loaded and bagged filter packs stored prior to shipment to field?____________________

14. Are any of the filters from Toronto ever damaged? (i.e. nicks out of the sides) If so what is done with them?____________________

V-2 SAMPLER CONFIGURATION CHECKS

SEQUENTIAL AIR SAMPLER AND SAMPLING BOOM

1. Are the sampling boom and suction lines in good condition?
   - Is the boom bent?____________________________
   - Do the suction lines have any kinks?_____________
   - Are the boom and tower still secure and steady? _____

   ____

   ____

   ____

2. Is there any kind of deposit or black ring on the walls of the air sampler rotometer?____________________

   ____

3. Are all lights on the sampler functioning properly?_____

   ____

V-3 INSTRUMENT CHECKS

SEQUENTIAL AIR SAMPLER AND SAMPLING BOOM

Note - Record results on Data Sheet

1. Type of Check - Calibration of Rotometer

   Checked by: Turn off sequential sampler and disconnect one suction line from the back of the sampler. Place 0-50 l/min mass flowmeter (mass flowmeter should be previously calibrated using a bubble meter) in line and re-connect suction.

   Turn sampler and mass flowmeter on and allow 20 minutes for warm-up. The output of the mass flowmeter should be connected to a digital voltmeter (scale 0-5 VDC).

1) cont'd

Using the flow controller on the sampler perform a multi point (10 values) calibration allowing 30 seconds per reading to allow flow rate to stabilize. The calibration range should cover 20-30 ℓ/min.

2. Type of Check - Calibration of Volumetric Counter (Gas Meter)

Checked by: The instrument set-up for calibration is the same as in the "Calibration of Rotometer" except that once the flow controller has been set to approximately 25 ℓ/min it should not be adjusted. The sampler should run for approximately thirty minutes with each time the volume counter changes (every 10 ℓ or approx thirty seconds) the time and flow rate should be recorded.

3. Type of Check - Leak Test

Checked by: This test determines whether there is any flow leakage through one sample channel while sampling is being carried out on another channel. Seven of the eight sampling ports are interconnected through a manifold which has one inlet. If any flow is to enter any of the seven sampling

3) cont'd

channels the flow must be drawn in through the one inlet on the manifold. The inlet on the manifold is connected to a flow sensitive meter (0 - 500 cc/min mass flowmeter is adequate). The sequential sampler is then turned on. The sampler should be cycled so that the port not connected to the manifold is sampling. No flow should be indicating on the flow meter attached to the inlet of the manifold. The sampling port should be sealed by placing a finger over the inlet and observing if there is any flow through the flowmeter attached to the manifold. (Note to prevent damage to the sampling pump the inlet should not be covered for more than 10 seconds at a time). If any flow is observed the flow lines attached to the manifold should be blocked until the sampling channel that is allowing flow can be determined.

Any channel reporting leakage, should be noted on the data sheets and also reported to the regional technician so that the sampler can be repaired or replaced immediately.

SEQUENTIAL SAMPLER DATA SHEET

SITE____________________ DATE________________

MANUFACTURER____

MODEL NO.____

SERIAL NO.____

ROTOMETER CALIBRATION

Reading #	Rotometer Reading (ℓ/min)	Voltmeter Reading (VDC)	Mass Flowmeter Reading (ℓ/min)
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			

VOLUME COUNTER CALIBRATION

Reading #	Time Minutes & Seconds	Volume Reading (ℓ X 10)	Vol & Meter Reading (UDC)	Mass Flowmeter Reading (ℓ/min)
1	0' 0"		0.0	0.0
2				
3				
4				
5				
6				
7				
8				
9				
10				

LEAK TEST

Channel #

Sampling Channels leaking ____________

____

____

APPENDIX VI

RESULTS OF SITE VISITS AND AUDITS

HURON PARK   DATE OF VISIT: April 7, 1982

Site (3/10)

- Site located at Centralia College of Agricultural Technology
- Open, flat area with no windbreak
- Close to fields used by agricultural students. These fields are plowed, fertilized and sprayed with various types of pesticides.
- A small industrial park located 180 m to the west of the site.
- Various industrial activities (boat manufacturer, bottling plant and car parts plant). Also a small airport ∼ 2 km west of site

Operator (9/10)   Malcom McAlpine

- Good operator
- Follows sampling protocol with little or no deviations from it.
- Checks instrument daily and records any instrument problems in his log book.
- Operator understands the reasoning for all the special precautions and is careful not to contaminate sample.
- He believes that he was well trained and would like to be taught some instrument troubleshooting. He would also like to see some feedback on entire program. Operator ran out of long bags therefore had to switch to short bags 1 month early.

Instruments (4/10)

Sangamo

- Instrument did not have a stand for operator to work on. U-bolts not galvanized, rusty, should be changed.
- Hood movement starts smoothly then jerks midway.

	- Motor runs on for 10 s after hood has covered bucket.
	- Poor seal observed on both buckets.
	- Operator had problem with limit switch in fall, it was short circuting instrument.
Standard Rain Guage	- Level and bottom of rain guage touches snow.

MOUNT FOREST DATE OF VISIT: April 7, 1982

Site (6/10)

- Site is located at CLIMAT station in Mount Forest on Hwy #6.
- Open area with no windbreak and approximately 120 m from Hwy #6.
- Ground cover is cut grass (lawn). C.P.R. railway tracks less than 100 m from site.
- Corn field approximately 1/2 km N of site.

Operator

- Site audit only, as operator could not meet with auditor at 5 pm.

Instrument (5/10)

Sangamo

- Sampler not level
- Hood movement not smooth rather jerky and tended to drop suddenly.
- Motor not running properly and produced a squeaking noise.
- Poor seal on dry bucket.

WILKESPORT DATE OF VISIT: April 6, 1982

Site (6/10)

- Site located at East Sombre Public School on county road 31 just south of Wilkesport.
- Area surrounding site is flat and open with no windbreak.
- Plowed corn fields to the north and south of site, soya bean field 500 m to the west and a pasture for cattle to the east.
- The corn fields are fertilized with liquid nitrogen and sprayed with pesticides.
- Oil refineries with plumes and flare stacks are located 10 km N.W. of site

Recommendations

- Check agricultural activities and if possible note plowing and spraying activities on sample sheets

Operator (8/10) Jim Townsend

- Good operator, everytime he changes samples he brings the manual out to the instrument and follows it step by step to insure that he is doing it properly. Result of sample changing produces a well fitted properly installed bag.
- Manual however has not been updated since he first received it therefore any changes in protocol have not been followed. Well kept log book in which he makes an entry at least once per week with regards to instrument status and present weather conditions.
- Every Wednesday he checks limit switch, fuse and sensor grids.
- Operator would like more formal training and periodic feedback.

Instrument (4/10)

Sangamo

- Sensor grids were cold to touch and there was no pulsing current through them.
- Hood did not move smoothly from bucket to bucket and tended to jerk a bit midway (the chain was skipping).
- Buckets were not level
- Day before audit, there had been a snow storm and no precipitation was found in wet bucket, however there was quite a bit of snow in dry bucket.

Storage Guage

- Round and level

Metrex Low Vol.

- Dirt accumulating in filter pack casing (cover)
- Unable to disconnect tubing to install mass flow meter in line, therefore no calibration

MATTAWA DATE OF VISIT: May 13, 1982

Site (3/10)

- Site is located on private property behind a variety store on Calvin/Papineau Township road.
- Instruments are located in an open area with some windbreak to the S.E. of sampler.
- Poor ground cover, not level and very sandy, generating much windblown dust, both wet and dry bags were visually dirty from dust and dirt at time of audit.
- Road to the west/north-west is graded weekly, sprayed with liquid calcium at least twice during the summer and is plowed and salted during the winter.
- Snow accumulates at site and at times covers the low volume housing. Level of snow may be as high as 0.5 m from the filter pack.

Recommendations

- Improve ground cover at site by planting grass and leveling area
- Advise operator not to burn garbage near site
- Watch snow drifts
- Move site further from road.

Operator (7/10) John Brayshaw

- Good operator
- Seems to follow sampling protocol and is careful not to contaminate sample when changing bags.
- He cleans the instrument regularly and checks to see that it is operational twice a day.
- When instrument malfunctions he watches technician repair it and said that he would like to be taught a bit of troubleshooting. Often he and technician go over sampling protocol to insure that there have been no changes in protocol.

- Operator burns garbage approximately 10 m from instrument site and says that when he does this he covers the Sangamo with a tarp.
- He is very concerned and interested in the program and would like to see some formal training and periodic feedback.

Instruments (5/10)

Sangamo	- Sensor grids very warm to touch. - Hood does not move smoothly - has jerky motion and drops suddenly. - Hood not held in place properply - pin pops out occasionally.
Storage Guage	- Round but not level. - Operator left ruler in guage and it soaked up much of the oil.
Metrex Low Vol.	- Low Vol housing placed on a stand near filter pack.

PALMERSTON DATE OF VISIT: April 7, 1982

Site (6/10)

- Site is located at Palmerston Regional Centre on the west side of Hwy. 23 just south of Palmerston.
- Large open area, grass covered with very little windbreak. At instrument site there is some exposed soil and grass is not trimmed or cut.
- Corn fields which are plowed, fertilized and sprayed with pesticides surround the site to the west and south.
- Sewage lagoon approximately 100 m north of site and a few coniferous trees to the east of site.
- Windblown dust has been a real problem at this site.
- At time of audit dirt and dust was visible in both the wet and dry buckets.
- Site is however well removed from any large industrial sources.

Recommendations

- Plant grass at instrument site and insure that grounds are maintained.
- Move sampler further away from lagoon and improve windbreak.

Operator (3/10) Stan Freeland, Doug Scott

- They were new operators and were never trained or shown proper sample changing procedure, resulting in an improperly installed, poor fitting bag.
- Operators wear only one pair of poly gloves through entire operation.
- During winter months operators say that they change samples as quickly as possible therefore, care is not taken and contamination may result.

- Operators do not clean the instrument, knife edge, gasket or sensor grids even though this site has a definite problem with windblown dust.
- They are however, interested in the programme and feel that they need some formal training and feedback.

Instruments (6/10)

Sangamo

- Gasket seal was very poor and hood sat approximately 3 mm above the buckets.
- Bags were not held down by bungie cord, tape or cable ties.
- Hood moves relatively smooth then drops suddenly.

Storage Guage

- During winter months storage guage had been completely covered in snow and measurements could not be taken.

Metrex Low Vol.

- Low Vol sampler housing covered with a plastic bag and placed on Sangamo stand.
- Poor seal between sampler housing and tubing connected to filter pack.

KILLARNEY DATE OF VISIT: May 14, 1982

Site (7/10)

- Site is located at Killarney Mountain Lodge next to the Lodge office.
- Sampler is on top of a small rocky, moss covered hill.
- It is surrounded by a few bushes to the east and west, a small marsh to the north-west, and the Georgian Bay 50 m to the south-west.
- Site has some windbreak to the north east.
- During the winter months the snow tends to accumulate at site making accessibility to the instruments difficult for operator.

Recommendations

- Clear a path to instruments during winter period to improve accessibility for operator.
- Watch snow drifting at site.

Operator (4/10) Fred Schregardus

- He does not follow sampling protocol and uses the same pair of poly gloves during entire sample changing operation.
- Did not know why Technician left him DI H_2O and ETOH, was not aware to the fact that he was suppose to clean the instrument, gasket, sensor grids, and knife edge.
- Operator does check instrument once a week by activating it but does no other instrument checks.
- Operator makes only one log book entry per month and does not record any general observations
- Interested in program and would like to see a bit more training and some feedback.

Instruments (5/10)

Sangamo - Slightly off level, sensor grids very warm
- Hood movement not smooth, drops suddenly and slightly rusted
- Chain for motor skips
- Plunger on limit switch was deformed
- Sensitivity high (330 KΩ vs 220 KΩ)

Storage Guage - off level

Metrex Low Vol. - Sampler housing on a stand near filter pack

RAILTON DATE OF VISIT: April 26, 1982

Site (3/10)

- Site is located in a rural area approximately 12 km from Little Cataraqui on private property. Area is open, flat and grass covered with windbreak to the south and west of sampler.
- Gravel driveway approximately 3 m south of sampler
- A few deciduous trees found to the north and east.
- At the time of audit, the operator was in process of constructing an auxillary building approximately 4 m east of site, thus, increasing the amount of activity at the site (i.e. sawing wood, pouring concrete etc.). Once completed it would be a severe obstacle to sampling and a significant violation of the siting criteria.

Recommendations

- Move the site further away from auxillary building and gravel driveway. Insure that grounds are maintained and grass is kept to a reasonable height.

Operator (6/10) Reg Genge

- Operator generally follows sampling protocol
- Only deviation is that he does not label the samples immediately at the site - instead he waits until he gets to the M.O.E. office in Kingston. Regional Technician transfers sample from bag to bottle then labels sample.
- Operator log book and data sheets are also kept at the M.O.E. office rather than at the site as a result several days may pass before information is recorded. On weekends when events occur operator does not refrigerate samples, he lets them sit at ambient air temperature in his garage. Changes sample at 07:30 hrs.

Instruments (5/10)

S E S	- Sampler orifice is round and level - Improper bag fit, bag is not flattened against the sides of the sampler and sits approximately 4 cm above the bucket.
Aerochem	- Not operational at the time of audit
Sangamo	- Special Study - Loosely fitting hood does not produce a good seal. - When hood moves from one bucket to the other it stops midway for approximately 15 seconds then continues to move towards bucket (jerky motion, not smooth). - Hood gasket does not cover bucket properly and can be easily moved up or down by a gentle blowing wind. Limit switch plunger slightly deformed and adjustable screw did not make contact with the plunger properly.
Nipher	- Instrument not level - Operator built a stand for Nipher to improve accessability during winter months. - Collection container properly installed.
Standard Rain Guage	- Was to be installed May 1, 1982.

PORT STANLEY DATE OF VISIT: April 6, 1982

Site (6/10)

- Site located at M.O.E. filtration plant east of Port Stanley on County Road 24.
- Sampler is in a small valley with a gentle rolling hill from the north - evidence of drifting snow.
- Filtration plant (oil heated) approximately 300 m north.
- Area surrounding site is agricultural. Corn fields to the north and east, wheat fields to NE and tobacco fields to the west. These fields are plowed, fertilized with NH_3 and sprayed with herbicides and pesticides.
- Lake Erie approximately 1 km south of site.
- Parking lot approximately 30-40 m NW of site was being snow blown at time of audit and snow which was being cleared from parking lot was activating the sampler.

Recommendations

- Watch drifting snow near sampler
- Make arrangements to avoid snow blowing contamination

Operator (9/10) John Apfelbeck

- Operator's rating is good to excellent. He follows sampling protocol with no deviation and is careful not to contaminate samples.
- He checks instruments daily and records general observations in his log book. He would like to see some periodic feedback on the program as a whole.

Instruments (5/10)

Sangamo

- Sensor grids were not warm to touc[illegible]re was no pulsating current and they were sl[illegible]iscolored (black). There is also an electrica[illegible]blem at site - recurring circuit breaker tripp[illegible].

	- Auditor noticed quite a bit of snow had accumulated in the dry bucket and not as much in wet bucket. The night before the audit there was a snow storm and there should have been more snow in wet bucket.
Storage Guage	- not on a stand - Orifice is not round or level
Metrex Low Vol.	- Low volume sampler housing placed on brick blocks to prevent it from freezing to the ground and becoming buried in snow. - Plastic bags placed over housing - Tubing was frozen to pump and therefore auditor was unable to complete flow calibration.
Bulk Sampler	- 1.5 m above ground made of galvanized steel - bag held down by bungie cord.

MILTON DATE OF VISIT: April 5, 1982

Site (5/10)

- Site located in an agricultural/residential area approximately 0.5 km south of Hwy. 401 next to the Agricultural Museum.
- Open area which is not flat and has no windbreak.
- Ground cover at site is long hay-like grass. Operator believes that it is cut during the summer months.
- Gentle rolling hill to the NW of sampler with a run off area just south of sampler.
- Breaker box is in the basement of a private home approximately 150 m N of site therefore not easily accessible when there are power problems.
- Corn fields approximately 1 km N of site and Niagara Escarpment approximately 1-2 km SW of sampler.
- Site is too close to large Highway #401.

Recommendations

- Move to an area which is flat level and further from Hwy. 401
- needs more windbreak
- Power needs to be made more accessible.

Operator (9/10)

Brenda Brobst

- Operators rating is good, seems to follow sampling protocol when changing bags and cleaning instrument
- Operator is careful not to touch bags and contaminate samples
- Site and instruments are checked weekly.
- During winter months when bags rip or tear operator fixes bag by covering damaged bag with tape.
- Operator takes four storage guage readings then averages them - sometimes readings deviate by as much as a centimeter.

Instruments (1/10)

Sangamo	- Stand not sturdy
	- Sensor grids were not warm to touch, instrument was not level and a poor gasket seal obtained because of improper bag installation.
	- Site has had electrical problems in the past - short circuit and sets off breaker.
	- Breakers are not easily accessible to operator or technician.
	- No knife edge collar
	- Improper bucket installation
Storage Guage	- Orfice was round however, instrument was not level.
Metrex Low Vol.	- Stand for filter pack not level and a gray ring was noticed on the rotameter.
	- Low volume sampler housing buried in ice and snow - may be responsible for instrument failures.

NORTH EASTHOPE DATE OF VISIT: March 30, 1982

Site (8/10)

- Site is located on private property in a rural area 3 km east of Hwy 19 in North Easthope township.
- Excellent site with good windbreak towards the north east and south.
- Area is flat and ground cover is fine trimed lawn.
- No sources nearby that could contaminate samplers with the possible exception of plowed fields approximately 250-300 m east of site.
- Swimming pool approximately 80 m east of site could also contribute to possible Cl^- contamination.
- Auditor noticed evidence of snowmobiling within 1 m of sampler

Operator

- Site audit only

Instruments (5/10)

S E S

- Orifice was not round and instrument not level
- S.E.S. bags left under S.E.S.collector - probably old bags used for sampling (no precipitation) but it should be checked with operator.

Nipher

- Approximately 2 m above ground,
- Level is off by 34 mm (E-W) and 50 mm (N-S)
- Orifice round
- Stand was not sturdy
- Inside Nipher container improperly installed
- Top sat above nipher shield

WATERLOO DATE OF VISIT: March 30, 1982

Site (7/10)

- Site located at Laurel Creek Nature School approximately 5 km from Waterloo. Land at site is flat however in a bit of valley.
- There is a 10-15 ft mound approximately 20-30 m N.W.
- Ground cover at site is milk weeds and hay-like grass up to 1 m tall. Fine trimmed lawn west of sampler and grass to the north, south and east.
- No windbreak in immediate area - sparce deciduous and coniferous trees approximately 75-100 m away.
- Oil heated brick school house approximately 50 m SW of site.
- Very close proximity to kitchener-Waterloo, approximately 3-5 km to City Center.
- Transformer station 3 km SE and rubber plant 6.5 km SE

Recommendations

- Maintain grounds, cut weeds within 10 m radius of sampler
- Consider improving windbreak around sampler.

Operator (9/10) K.C. Deboer

- Operator rating is good to excellent. Follows sampling protocol and is careful not to contaminate the sample. Operator cleans instrument properly and checks that it is operating at least once a week i.e. activates sampler and checks sensor grids.
- Well kept log book in which entries are made weekly and operator notes instrument response and present weather conditions - he also records when events occur and records the ppt amounts (APIOS should request this data from him).
- Storage guage measurements are taken properly and operator takes supplementary measurements after each event and records this information

- Operator would however like to see some feedback with regards to the program. He believes that the information could be very useful to the Nature School located near the site.

Instruments (9/10)

Sangamo	- Instrument in good working order - Sensitivity resistance is quite low (120 k vs 220)
Storage Guage	- Orfice is round and instrument is level however auditors did notice bits of pollen and organic debris in storage guage.

SMITHS FALLS DATE OF VISIT: April 27, 1982

Site (2/10)

- Site located at Montague Public School north of Smith Falls on County Road 4
- Immediate area is flat and grass covered
- Corn fields which are plowed and sprayed found to the north and east of site
- Hay field to the west of site on sloping ground
- Hydro pole approximately 15 feet from sampler
- Overhead wires pass directly over sample container
- No windbreak

Recommendations

- relocate site on operators property
- potential site has good windbreak
- no vandalism
- further away from fields

Operator (9/10) Dane Stairs

- Excellent operator
- He follows sampling protocol and is extremely careful not to contaminate samples.
- Checks instrument twice a day
- Cleans gaskets, instrument body and sensor grids every second or third day
- Well kept log book, entries made daily - everytime there is an event, power failure or instrument problem
- Very interested in program and would like to see more formal training and feedback.

- Storage guage measurements obtained by averaging two readings 90° from each other.
- Operator informs M.O.E. whenever anything happens pertaining to the site and sampling.

Instrument (8/10)

Sangamo - Overall instrument in good working order. However, hood was a bit sluggish when going from one bucket to the other. Stand for Sangamo not very sturdy and U-bolt missing. At time of inspection it was spitting rain and Sangamo seemed to be operating properly.

Storage Guage - Not quite level

Metrex Low Vol. - Operator says that water tends to collect on the top of the low volume filter pack.

WELLESLEY DATE OF VISIT: March 30, 1982

Site (5/10)

- Site is located at a sewage pumping station approximately 2 km south of Wellesley. Slightly negative ground slope from north to south where snow drifts accumulate. These drifts may reach the height of the sampler during the winter months.
- Aerated sewage clarifier tanks are approximately 47 m from sampler and at the time of audit a prominent odor (manure) was noticed.
- A parking lot (paved) 10 m west of site is snowblown in winter and operator said that sometimes the snow which is blown accumulates in sampler
- A chimney 15 m west of sampler which emits exhaust was also identified by operator as a potential source of contamination
- Corn and wheat fields which are plowed, fertilized and sprayed with pesticides (Adrezene) surrounds the site to the north and east.
- The land between the Nith River and site is in the flood plain and is grass-bush covered to the south.
- No windbreak at site as it is in an open area. A small gravel pit is approximately 3-4 km SE of the site.

Recommendations

- Move sampler further away from the building and tanks.
- Cover when generator is tested

Operator (5/10) Richard Garstin

- Overall operator rating is fair as he does not follow sampling protocol.
- Throughout sample changing procedure operator wore only one glove and did not change it at any point. He actually put dirty glove in bag.
- When removing bungie cord operator did it in such a way that contamination could result (i.e. snow knocked into bag).

- Operator changes samples at 05:30 daily rather than 08:00 and checks site twice a day.
- When decanting sampler, operator did not swirl bag nor did he clean the corner of the bag and scissors.
- The sample is then refrigerated until it is picked up by Technician.
- Nipher measurement done properly
- Log book is kept at operators home rather than at the site, therefore information is not reocrded immediately. Information from the data sheets as well as any general observations are noted in log book.
- A very concerned operator. He cares about the program, would like more training and periodic feedback.

Instruments (6/10)

S E S	- Orifice is not round or level and stands approximately 1.5 m above ground (1.0 m above snow).
Nipher	- Sample orifice was round and is about 2 m above ground - Stand was level - Collector properly installed
Aerochem	- Not operating at time of audit
Standard Rain Guage	- Not operational at time of audit.

WHITMAN CREEK DATE OF VISIT: April 26, 1982

Site (7/10)	- Site is located at a goat/dairy farm approximately 14 km from Harrowsmith on county road #7 (∿ 20 m) - Open, grass covered area with no windbreak - In a bit of a valley with a gentle sloping hill to the northeast. - Grassed area around the sampler not cut or maintained and chickens are allowed to run free in this area. - Goat pen approximately 10 m from sampler therefore close proximity to farming activities
Recommendations	- Proper fencing installed around sampler to prevent animals from getting too close to samplers - Cut grass and maintain area around sampler
Operator	Mrs. Angement - Site evaluation only, however auditor did notice that the S.E.S. sampling bag was improperly installed. Bag held down by bungie cord - poor fit - orifice size reduced and bag extended past the top

Instruments (6/10)

S.E.S.	- Sample orifice not round and instrument slightly off level - Poor bag fit
Nipher	- None
Aerochem	- Not operational at time of audit

KALADAR DATE OF VISIT: April 26, 1982

Site (8/10)

- Site located on private property 3.5 miles north of Kaladar on the east side of Hwy. 41.
- Flat area immediately to the north of sampler is a marsh
- Deciduous trees to the north and east of site. Hay-like grass (up to 0.5 m high) surrounds site
- Close proximity of site to Hwy. 41 (∿ 150 m)
- Good windbreak to the north, south and east open towards the highway to the west.

Recommendations

- Insure that grass is kept to a reasonable height

Operator (6/10) Ward Lloyd

- Overall operator rating is good. He follows sampling protocol and is careful not to contaminate samples
- Sample changing results in a properly installed, well fitting container. Operator however does not clean instrument.
- Instrument checks consist of visual checks from the house when an event occurs, if in doubt he goes outside and checks it.
- No routine checks (time, sensor grids, etc.) are performed.
- Well kept log book - notes when events occur and instrument failures.
- Does not feel that he was adequately trained - would like more training and feedback from programme.
- Operator takes only 1 storage guage measurement (he does not average several) however the measurement is always taken at the same spot in the guage.

Instruments (8/10)

Sangamo	- Overall instrument is in good working order. However hood does tend to drop suddenly when going from dry to wet side - Large gap in knife edge collar
Storage Gauge	- Orifice is round but slightly off level - On a stand 0.5 m above ground
Metrex Low Vol	- Covering over filter pack cracked - Pump box placed on Sangamo stand - Pole holding filter pack not sturdy

DALHOUSIE MILLS DATE OF VISIT April 25, 1982

Site (5/10)

- Site located on private property approximately 2.5 miles south of Glen Robertson on County Road 18.
- Flat area with plowed corn fields to the north, dormant fields with hay-like grass to the east, a creek to the south and pine and decidious trees to the west.
- A bit of windbreak to the west however none towards the north, south and east.
- In a rural area approximately 45 km from Cornwall
- Site is located on the edge of a river valley
- Garden immediately adjacent to sampler

Recommendations

- Improve windbreak if possible
- Check gardening activities and note plowing or spraying of fields on sample sheets.

Operator (3/10) George Hambleton

- Poor operator. He is not totally familiar with sampling protocol. He does not use a new pair of poly gloves at proper times (potential contamination) and he reaches down into the long bucket in order to fix the bag thus introducing a potential source of contamination (i.e. his arm often touches inside of bag).
- Sample changing results in an improperly installed, poorly fitted container.
- Operator does not change sample at proper time or date and he is often away and therefore is unable to perform instrument checks or note exactly when instrument malfunctions occur.

- He does not seem to understand the reasoning for all the special precautions, i.e. gloves, cleaning bag, etc.
- Often changes samples at wrong times - i.e. 2 or 3 days early.
- Wondered if sampling time could be changed to a time which is more convenient for him!
- Does not feel that he was adedquately trained and would like to see some formal training and feedback on the programme
- Operator takes only one storage guage measurement (he does not average several) and does not take a proper temperature reading, i.e. stir the solution and take measurement 3-6" below surface

Instruments (4/10)

Sangamo

- Many problems in the past with regard to the electrical set up. Instrument frequently shorts out setting off ground fault circuit breaker.
- Hood tends to jerk and drop suddenly when going from one bucket to the other.
- Plunger on limit switch was slightly deformed and adjustable screw did not hit plunger properly. Sangamo stand was not very sturdy making it difficult for operator to change sample.
- Recently a heater was installed to aleviate moisture related problems
- Sangamo hood slightly rusted
- Large gap in knife edge collar

Storage Guage

- Round but off level
- Not on a stand but at ground level

Standard Rain Guage

- On a small sloping hill 0.5 m above ground and off level

Metrex Low Vol.

- Housing kept on Sangamo stand
- Children from area have been know to tamper with low vol and turn instrument off
- Instrument malfunctions frequently

WILBERFORCE DATE OF VISIT: June 11/82

Site (6/10)

- located near Hwy. 648 in meadow on gently sloping hill
- difficult access in winter
- fair windbreak N and S of sampler, no windbreak E, W
- ground cover consists of high (upto 1 m) grass & weeds
- no obstructions to sampling or local industry
- dirt road (busy during summer) 70 m from sampler

Operator

- N/A - APIOS technician was looking after this site in the operator's absence

Instrumentation (8/10)

- good gasket seals and bag fit (wet & dry)
- good sensors, sensitivity,level, time delay
- one sensor was dirty -cleaned by auditors
- clutch not adjusted - (> 28 lbs.)
- storage gauge not level (no stand) slightly out of round

DORSET MOE LAB DATE OF VISIT: June 12/82

Site (8/10)	- well maintained APIOS special study site - located on flat area surrounded by large hills to N, S and W and large lake to east - ground cover - grass/weeds up to 0.5 m - cut as required - good wind break - lightly travelled graved road near samplers (∿ 60 m E and S) - site to be moved ∿ 800 m summer 1982 into new compound - also excellent site
Operator (9.5/10)	- J.P. Varto - APIOS senior technician
Instruments (9/10)	- special study site with several of each type of instrument - All are maintained on a regular basis by APIOS technician

DORION DATE OF VISIT: June 22/82

Site (8/10)

- located on flat river plain at Fish Hatchery
- ground cover - grass and weeds (∿18" high at visit)
- no agricultrual activity in immediate area
- good windbreak, no obstructions
- gravel parking lot ∿ 50 m NE of sampler -significant vehicular traffic in summer
- 15 m flag pole ∿ 50 m w of sampler

Operator (9/10)

- excellent sample handling
- excellent log book - includes weather station data
- low vol sampler not shut off during change-over

Instrument (8/10)

- occasional GFIC failures
- sensor, time delay, sensitivity were all satisfactory
- clutch not adjusted (> 28 lbs.)

NAKINA DATE OF VISIT: June 22/82

Site (2/10)

- located in residential near east end of town (pop. - 1000)
- surrounded by houses (oil and woodstove heat)
- hydro lines pass immediately over collector
- town is used as railroad marshalling yard - significant emissions from trains - particularly during stable conditions in winter
- children often play near sampler

Operator (9/10)

- Leo Matthews
- observes good sample handling procedures for precipitation and air samples
- changes samples at proper times
- good log book

Instruments (6/10)

- instrument level, good bag fit wet-side
- dry bag extends above bucket and sticks to gasket
- sensitivity high ~ 400 K Ω
- clutch slips
- low volume filter pack mounted very close to sangamo

Recommendations

- data from this site should be examined to see if contamination is occurring
- if contamination is observed, a new site should be found

ELY/FERNBERG, MINN DATE OF VISIT: June 24/82

Site (9/10)

- NADP site in 80 m forest clearing on top of moderate hill in rugged, hilly area
- excellent windbreak
- good access by operator
- some problems with severe storms

Operator (8/10)

- Jim Holzman, Ed Marsolek
- good sample handling procedures
- well trained by NADP and APIOS

Instruments (8/10)

- Aerochem, sequential sampler, Sangamo on site
- slight gap in gasket seal on Sangamo
- Sangamo stand loose, slightly off level
- sensors, sensitivity time delay and clutch adjustment, hood movement all satisfactory
- no storage gauge on site

LAC LA CROIX DATE OF VISIT: June 23

Site (3/10)

- located on bridge over bay at trading post on Lac La Croix
- sampler $\sim$ 4 m above water surface
- boat and airplane traffic near sampler
- poor security potential contamination by lodge guests
- difficult access - technician must fly in therefore limited number of visits

Operator (2/10)

- Laura Mutz
- poor sample handling procedures leading to potential sample contamination
- samples often changed at wrong times or on wrong days
- very poor log book
- no instrument cleaning - rain gauge particularly bad
- poor bag fit
- does not record trace events
- good sample transfer and storage

Instruments (6/10)

- Sangamo and Aerochem Metrics
- Samplers level
- poor gasket seal on Sangamo - ¼" gap
- sensor grids burnt out - replaced during audit visit
- "jerky" hood movement
- no storage gauge at site
- clutch adjustment, hood movement sensitivity and delay time O.K.

LAC LA CROIX DATE OF VISIT: June 23/82

- instruments need to be cleaned more often

Recommendations	- a new site and operator should be found for this area

POOR

QUALITY

ORIGINAL